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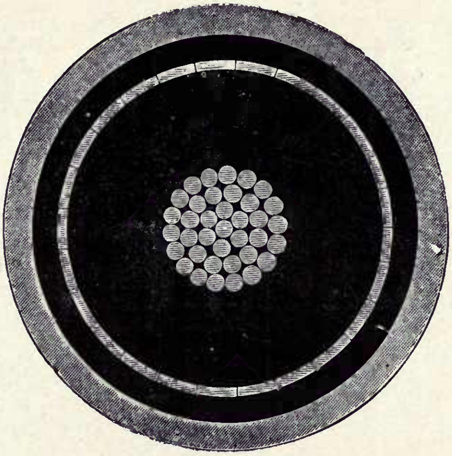

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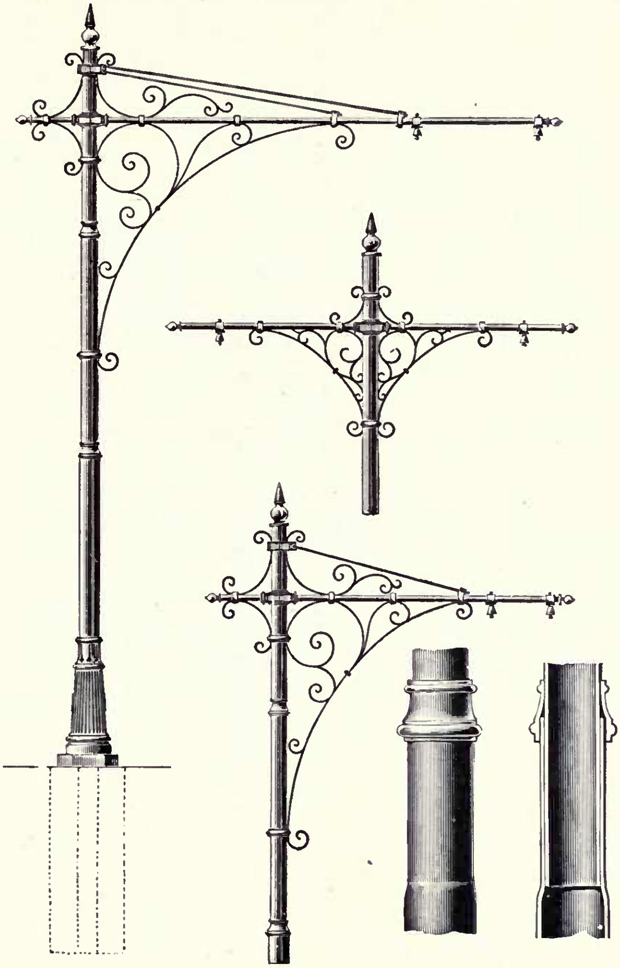

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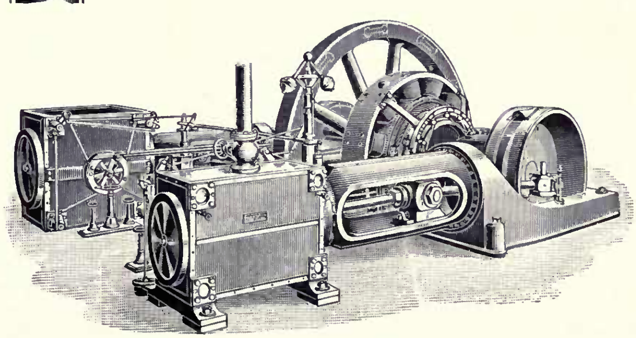

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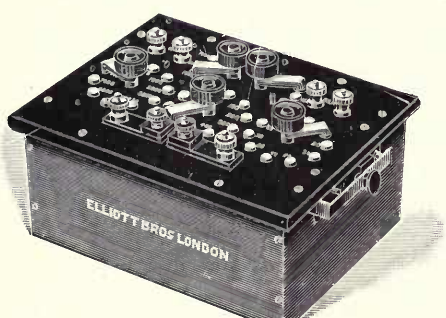

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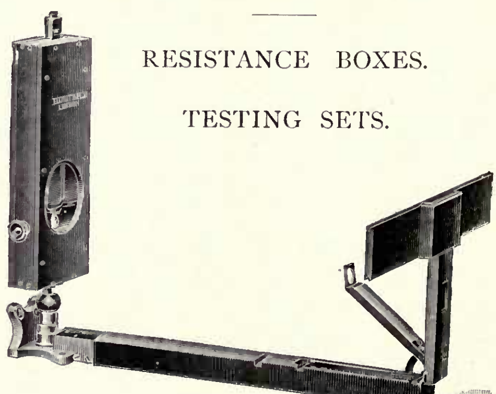

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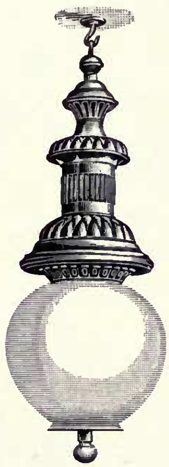

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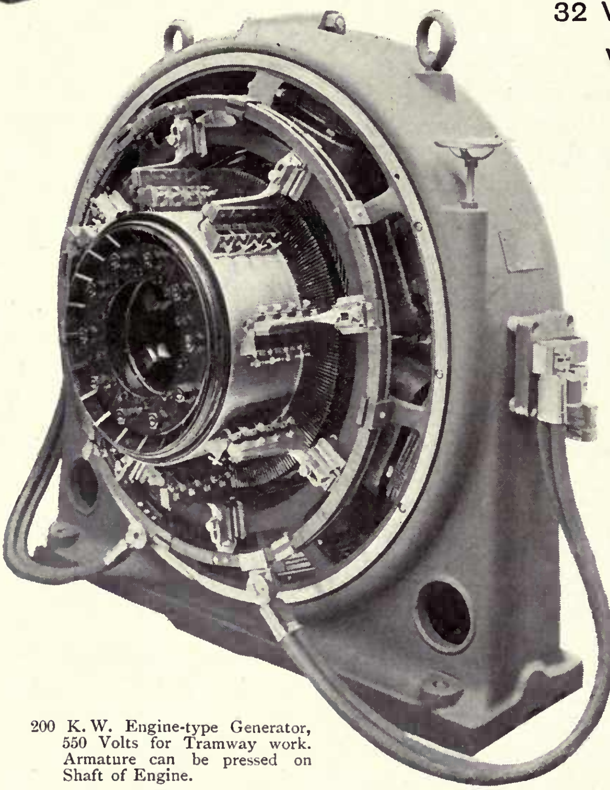

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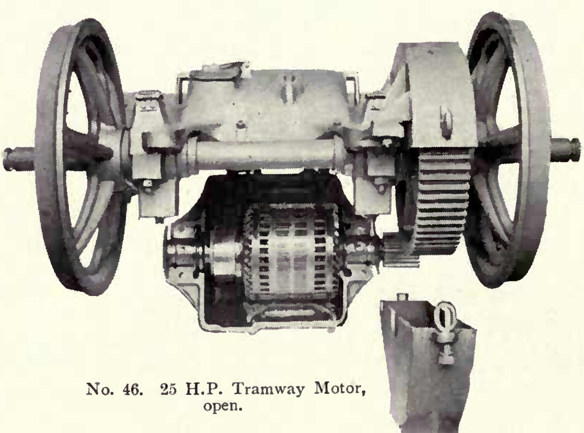

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A PRACTICAL HANDBOOK

FOR THE USE OF ELECTRICAL ENGINEERS TO MUNICIPAL CORPORATIONS AND MEMBERS OF MUNICIPAL ELECTRICITY COMMITTEES.

BY

ALFRED H. GIBBINGS,

Past President of the Municipal Electrical Association;
Member of the Institution of Electrical Engineers;
Membre de la Société Internationale des Electriciens, Paris;
Member of Council, Northern Society of Electrical Engineers;
Electrical Engineer to the City of Bradford.

BRADFORD:
PUBLISHED BY THE AUTHOR.

1899.

PREFACE.

THIS work, the first five Sections and Section X. of which originally appeared in a modified form in the columns of *The Electrician*, has been written and compiled mainly, but of course not exclusively, for the use of members of municipal electricity committees. The object aimed at is the elucidation of certain commercial aspects of electricity supply, which often fail to be understood, because they rest on technical bases. My experience teaches me that it is the want of a full, exact, and comprehensive knowledge which accounts in too many cases for a hesitating and unbusinesslike policy on the part of electricity committees.

I have therefore endeavoured to present the matter in such a form that the ordinary business man may gain some idea of the peculiar conditions which render the supply of electric energy different from that of most marketable commodities. Recognising the widely different circumstances under which both the generation and distribution of electricity is carried on in various parts of the country, I have treated the subject in as general a manner as possible.

For information given, loan of blocks, diagrams, &c., I am indebted to several municipal electrical engineers, and also to the kindness of the following firms and gentlemen :—

Messrs. J. H. Holmes and Company, Newcastle-on-Tyne ;
,, Wilmshurst, Hollick and Company, London ;
The Reason Manufacturing Company, Brighton ;
The Proprietors of *Electricity ;*
Messrs. R. Crompton and Company, Chelmsford ;
Mr. G. J. T. Parfitt, The Avenue, Keynsham, Bristol ;
Mr. R. J. Wallis-Jones, 36 Great George Street, London, S.W. ;
Mr. Reginald Wilson, 66 Victoria Street, London, S.W.

Bradford,
April 1899.

A. H. G.

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INTRODUCTION.

Up to the present time municipal electricity committees in the majority of cases have given attention chiefly to the erection of works, the establishment of a system of supply, and the necessary additions and extensions of existing works consequent upon the rapid manner in which the demand for the electric light has progressed. This fact was amply borne out in the discussion on a Paper read by the author at the 1897 Convention of the Municipal Electrical Association, and entitled "Municipal Aids to Wiring." In the course of that discussion Alderman Higginbotham, Chairman of the Electricity Committee of the Manchester Corporation, said:—

"This was not a matter that touched them very much, because they were in the position of not knowing how to supply applicants for the electric light quickly enough, without going to look after customers. Applications were coming in so very fast that really they could not be overtaken."

From these remarks it will be seen that, notwithstanding the high price at which electricity is sold, the demand during the first few years from its inauguration has been greater than could be readily and conveniently met.

To prepare for and cope with this rapid increase of business has for the time absorbed the attention of municipal electrical engineers, to the exclusion of many interesting matters, and it has certainly precluded any necessity *pro tem.* to offer inducements by way of further popularising the electric light. Such a rush of applicants, however, cannot continue in any place for more than the first year or two.

The experience at Manchester must, however, be looked upon as somewhat exceptional, as at the same meeting referred to above it was stated that at Blackpool "the consumers were largely a shifting population, who hesitated to spend money upon other people's property, when a week hence they might be out of the town. The only way to induce those people to use electric light was to put in wiring free, and let them pay a rent for it." Similar experience had been obtained at Worcester, where "as a further inducement they had halved their meter rents, and adopted the demand indicator. They were also supplying free lamps."

When the enthusiastic eagerness of the first year or two has subsided consumers begin quietly to count the cost, and are already in many a town lifting up their voices against the prices charged. Happily in most of the larger cities and towns this outcry has been neither ignored nor neglected, but movements have already been made, and some of them involving great innovations, with a view of giving the consumer greater advantages and of helping to reduce the bill for current at the same time. It is the intention and purpose in these pages to consider what has already been attempted or accomplished in the direction just indicated, pointing out those instances in which any particular apparatus, or any special method of charging, has been found successful or otherwise. In addition to these subjects other phases of electricity supply will be touched upon, and references will be made to standard works and Papers which have been read before scientific societies, in order to bring more prominently than hitherto before the members of electricity committees the ever-widening possibilities in connection with the use of electrical energy.

As a matter of fact there are at present many of the smaller towns which have shown a true municipal enterprise in starting an electric supply station, but which are still in the unfortunate position of having to keep up a high price per unit, and of not being able even then to pay all revenue charges. This state of affairs is likely to remain unless some further incentive to use the current and so to increase the

consumers is adopted. The reason is probably not far to seek. It is most likely because the interest, sinking fund, and works charges are so much greater in proportion for a small station and town than for a large one; that is to say, the "standing charges" which include *interest*, *sinking fund*, *wages*, *rent*, *rates*, and *taxes*, and similar items are fairly "constant" whether the demand is of very short or very long duration, whether customers are many or few.

It is a fact that in most cases where a loss instead of a profit is made, the nature of the demand is of very short duration; shops and business premises, for instance, habitually close early in the evenings. It is also clear that the very highest economy and efficiency which could possibly be effected with the generating plant would not avail much, under these circumstances, towards reducing the percentage of loss. What is wanted to turn the tables from loss to profit is a widening out of the daily "peak," and a more extended use of electrical energy for other purposes than the production of light. It is this aspect of the subject and the various means to this end which it is proposed to dilate upon and to discuss in the following pages.

Extended business would add to the profits of the undertaking, if already paying its way, and would enable many a small though enterprising town to turn an unprofitable into a profitable concern.

SECTION I.

THE POSITION OF THE ELECTRICITY DEPARTMENT IN RELATION TO OTHER MUNICIPAL DEPARTMENTS.

It may be accepted as a general fact that all the main branches of municipal work are considered as entirely separate undertakings, for which, if the necessity arises, distinct and independent rates may be levied upon the public. Each department is conducted and controlled by a separate committee responsible for its acts and deeds to the Council alone. The work of each department, however, must of necessity, in a greater or less degree, overlap and be related to the work of the other departments. Hence it has come about that many special matters are dealt with by sub-committees whose work is supervised and controlled by a general committee. The duties relegated to such sub-committees usually relate to some specific and single subject; and, as an illustration, may be instanced a general works committee having under its management such matters as street improvements, drainage, sewage defœcation, street lighting, street cleansing, and road making.

The members which constitute a sub-committee are usually delegated on account of their individual qualifications or ability to deal with a specific question, and, with the exception of particular and complicated schemes which occasionally arise, involving largely the interests of other departments, a sub-committee can usually deal exclusively and satisfactorily with the business entrusted to it.

With the advent of electricity it was very naturally assumed that, as a section of municipal work, it could be as easily and readily dealt with by a sub-committee as were similar special and limited matters. It was taken for granted that its application would be confined to lighting purposes only, and hence in many corporations the supply of electricity has been considered merely supplementary to the supply of gas. The business, therefore, naturally fell into the hands of a sub-committee of the gas supply committee. This, of course, was all very well when municipalities were making their first attempts at electric lighting, but as soon as a supply was actually commenced it immediately became apparent that the uses of this new energy, far from being restricted to lighting purposes, were likely to be of even a more extended nature than the supply of gas or water. Its importance indeed grew so rapidly that it soon attained proportions equal to, if not greater than, any other department of the corporation. This has been found to be the case in Glasgow, Manchester, Liverpool, Brighton, Bradford, and in many other cities and towns. Out of all these, however, it has been due to Glasgow that the first attempt has been made to place the electricity committee upon a sound and proper basis for dealing with all the possibilities which come within its sphere.

On September 2, 1897, Lord Provost Richmond, of Glasgow, at a meeting of the Glasgow City Council, dealt at length with the problem, and his remarks are quoted as follows. He said—

"I would suggest as a designation for the proposed consolidated committee, 'The Tramways and Electricity Committee.' It would be composed of twenty-six members—one from each ward, with the addition of the Lord Provost to make the even number. For the present the twenty-five members would be taken from the existing committees in question. This would form a general, or parent committee, which would, first of all, be divided into two standing sub-committees, named respectively the 'Sub-Committee on Tramways' and the 'Sub-Committee on Electricity,' and it might be well in each case to secure continuity by retaining members on these sub-committees respectively who are

acting on the corresponding committees at present. The parent committee could again be equally divided transversely by appointing thirteen members to form a 'Sub-Committee on Finance,' which would deal with all the accounts of the various sections, and thirteen members to form a 'Sub-Committee on Production.' Each of these two sub-committees would be composed of six members from the Sub-Committee on Tramways and six from the Sub-Committee on Electricity, and in each case there would be the convener in addition. The parent committee would, while guiding and reviewing the entire policy of the whole (acting both under the Tramways Acts and the Electric Lighting Order, 1890), take up and deal directly with the production of electric current for all purposes; the delivery of the current required by each of the two standing sub-committees at the proper voltage at their respective switchboards, or as may be arranged; and the fixing of all charges for current supplied to or through these respective sub-committees, and the apportioning of all common or general charges. The Sub-Committee on Tramways would receive from the parent committee, at such points as may be arranged, all the current required for tramway traction. In all other respects this sub-committee would control and operate the Tramways Department just as the Tramways Committee does at present. The Sub-Committee on Electricity would likewise get current supplied by the parent committee at given points, and would distribute it in the supply of current for public and private lighting and for power, thus practically carrying on the work of the present Electricity Committee, apart from the production of current. The Sub-Committee on Finance would take charge of the accounts of all the departments of the committee. Separate books and accounts would, of course, be kept for the different departments, and each could have its own bank account. The Sub-Committee on Production would deal with the power stations and other works directly undertaken by the parent committee. Each of the four sub-committees might meet fortnightly, and the parent committee, as in the case of the Health, Water, and Gas Committees, monthly. I would suggest that the

present conveners and sub-conveners should occupy in the new department, as nearly as practicable, corresponding positions to those occupied by them at present. The following rearrangement of committees and sub-committees would give practical effect to this: Tramways and Electricity Committee, convener and sub-convener; Sub-Committee on Tramways, convener and sub-convener; Sub-Committee on Electricity, convener and sub-convener; Sub-Committee on Finance, convener and sub-convener; and Sub-Committee on Production, convener and sub-convener."

The foregoing remarks clearly show that the position of the electrical undertaking in Glasgow has become of the utmost importance in the affairs of that city, and, at the same time, those remarks are also a clear indication of what must shortly be experienced in other large cities and towns. Mr. Arthur Wright, of Brighton, carefully and ably expounded the speech just quoted, in an article entitled "The Centralisation of Electricity Supply," contributed to the *Electrical Review* of September 24, 1897. In that article Mr. Wright proposes a somewhat different adjustment of the control from that suggested by the Lord Provost. Mr. Wright would form a chief committee and call it "General Purposes Electricity Committee," entrusting it with the sale of electrical energy for all the requirements of the district. The formation of such a committee by one member from each ward, as proposed in Glasgow, would thus, he thinks, bring in gentlemen serving also on the several committees requiring electrical energy for the purposes of their respective municipal departments, but it is not suggested that this electricity committee should directly interfere with their sub-committees further than to see that their wants are properly supplied.

Mr. Wright further suggests that the chief committee should be divided into three sub-committees respectively, entitled—

THE SUB-COMMITTEE ON PRODUCTION,

having charge of the works and sub-stations;

THE SUB-COMMITTEE ON DISTRIBUTION,

having charge of the mains, feeders, connections, and meters ; and

THE SUB-COMMITTEE ON FINANCE,

having to do with all data, estimates, loans, and accounts. To quote Mr. Wright's own words :—

"This arrangement is strictly within the natural lines of development of our present practice under which the staff of the largest central stations are divided into departments in the manner indicated. The sub-committee on production should be responsible only for works-costs, regularity of supply, and the delivery of electrical energy into the mains at a proper pressure. The sub-committee on distribution should be responsible for pushing the business, for laying out the system of mains to the best advantage, and for the organisation of the delivery to departments of the corporation and private consumers in different parts of the district. It would be for the Sub-Committee on Finance to determine in regard to the supply of the tramways on the one hand, and the supply for lighting, power, &c., purposes on the other, the correct tariff based in each case on the amount of plant called into play at the works, the units taken from it, and the relation of the total distribution expenses to the two sets of mains, &c."

It is immediately apparent from the opinions just quoted, of a recognised authority upon municipal management on the one hand, and of the first President of the Municipal Electrical Association on the other, that it is not possible for one general committee to deal wholly and solely with all the business of any one department of a corporation. In some of the larger towns of the kingdom the attempt it is true is still being made, but in a few years the necessity will arise in all but the very smallest townships to form numerous small sub-committees, each of which will be separately responsible to a main or general committee, as already set forth. In the case of a great many municipal corporations the present position of the Electricity Committee can hardly be stated to be conceived on a broad or independent basis. It is indeed more or less a fact that corporations have been

forced into obtaining powers for the supply of electricity, or into using powers already granted to them, through threatened encroachment on their rights or imminent forestalling of their powers by private enterprise.

The inauguration of the business and the consequent formation of a committee to deal with it have thus been approached in a half-hearted manner, and hence small and inefficient "central stations" are the result. In many cases the municipality is also the owner of the gas works, and there appears to exist under such circumstances a great fear that the demand for electricity may seriously affect the welfare, and hence the finance, of the gas undertaking. Whilst this apprehension exists no large scheme of development can, of course, be expected, and the immediate consequence is that neither the best interests of the town nor of the two rival departments themselves will be served. A lame and halting policy is no better for a municipality than it is for an individual or a nation. If, however, we may judge from analogy, with any degree of confidence, the most rapid development of the electric light need give the gas department but little cause for fear. All new enterprises take considerable time in becoming really large undertakings, and meantime existing institutions hold their own with considerable tenacity. One of the London evening newspapers some time ago illustrated the fact very clearly, and it would be well for local councillors to take the lesson to heart. The extract is worth reprinting :—

"Consider illumination. If you look at the old iron barrows in the Mile End-road you will see offered for sale heaps of old-fashioned snuffers with the box for catching the wick. And the barrow merchants will tell you that there is a market for them. They are not bought by well-to-do 'cranks' who use snuffers as a matter of conservative obstinacy or family pride. They are not used by very poor people. The very poor prefer to endanger their already precarious lives by using low-flash oils in unstable lamps. No ; there is a public for these archaic implements. There are people in London who have not left off burning the old dip candle, which requires constant snuffing.

This takes us a long way back from the electric-light button behind one's pillow; but it is by no means certain that one could not go back further. Are rush-lights entirely disused in the British Islands? Anyhow, dip candles are still a cherished illuminator in London itself. After dips come composite candles, which are still in immense use. After composite candles we rise through a hierarchy of oil lamps—each 'patent' contemptuous of earlier ones—to gas. We have the ordinary gas flame, the albo-carbon flame, and the wonderful hooded flame. Then we come to the electric light in its many adaptations, not omitting the 'bus ticket-inspector's self-contained apparatus—noteworthy, because it marks the immense difference between the possibilities of gas and electricity. The ticket-inspector can carry his dynamos without inconvenience, but a pocket gasometer is an impossibility.

"It matters not where we look in this complex, ingenious, acquisitive, and yet conservative age—anomalies flourish together like flowers that bloom in the spring. We have a dozen ways of sending a message, each representing a stage of our national progress. We have still the rural postman in his cart and blowing his horn or whistle—Cornwall knows him well; we have the town postman, the express messenger, the telegram boy, and the telephone, the last-named being—so far as London is concerned—a most successful return to primitive unsatisfactoriness."

These observations are at least worthy of consideration, for underneath them there lies a very solid substratum of fact. For very many years to come there is room for both gas and electricity without the unbusinesslike method of crushing one for the sake of the other. The Gas Committee and the Electricity Committee should at any rate be entirely separate and distinct from each other in every township.

SECTION II.

THE WIRING AND FITTING OF PRIVATE PREMISES BY THE CORPORATION.

As a rule municipal electricity departments have not as yet extended their operations to include the wiring and fitting of private premises for the electric light and the supply of electrical goods generally. Many corporations are of opinion that to do so would be, in fact, travelling beyond their proper sphere, and that entering into direct competition with private enterprise is contrary to the spirit of municipal ownership and control. There are indeed very plausible reasons both for and against such a movement, and later on these reasons will be dealt with somewhat fully. Such a department as a branch of a municipal concern can of course be worked with profitable results, and this is no doubt a very important consideration to many small townships where the electricity undertaking is at present carried on at a loss. Local circumstances must, however, very largely affect the decision as to the advisability or otherwise of the Corporation itself undertaking the work of private wiring contractors. In some localities, for instance, the amount of wiring work to be done would not be sufficiently extensive to enable a good firm to open a branch of their business for the purpose, with a qualified staff of workmen. The wiring contracts under such circumstances are left to local tradesmen, plumbers, ironmongers, carpenters, &c., who probably have had no experience whatever of the distinctive features of good-class wiring work, and who can employ only casual and incompetent workmen.

As a matter of fact, some such state of affairs has existed in Derby, and which at the time called forth from the electrical engineer to the corporation the following letter, which appeared in the technical press :—

"I shall be glad to hear from fellow works managers who have been in the same difficulty as I am in, and how they overcame the same. We have in Derby two people who do electric lighting work, but wait until it comes in their way ; and it is hardly credible that one of our largest consumers had to write to me asking to know who were (if there were any) electric light contractors in the town. Derby is certainly a place for some enterprising man to start in."

This letter exemplifies how such a condition of affairs retards and handicaps the progress of the municipal undertaking itself.

The difficulty, however, which had been experienced at Derby has disappeared, as it is a large and important town. There are, however, many small towns with populations varying from 10,000 to 50,000, where the local authority, if also the owner of the electric light undertaking, might with advantage all round lend themselves to the work of the wiring contractor. One of the advantages would be that no cheap and inefficient work would be undertaken, which, in the long run, is a matter of no small importance. In answer to the author's inquiries, the experience of those corporations who have adopted the system are herewith given. The townships and vestries which do wiring work are—

1. Corporation of Bolton.
2. Corporation of Leicester.
3. Vestry of Shoreditch (London).
4. Liverpool.

The Corporation of Bolton make the following statement with reference to their wiring department :—

"We do not trouble about canvassing, although we do 95 per cent. of the work. We charge a fair price for our work, and it is guaranteed to be of the best. In Bolton we have no wiring firms

of any standing. In consequence of our doing this work, we find that the other contractors do not canvass. This is the only disadvantage in my opinion, but it does not make much difference to us considering we have put on over 13,000 lamps during the past twelve months. If the business gets slack then we shall consider the advisability of canvassing. Up to the present time we have kept eighteen men and assistants fully employed in work, and at present we have more work in hand than we can cope with.

"Another advantage gained by doing wiring is that should anything go wrong our customers have only one party to deal with, viz., the Corporation. In cases where outside firms have done the work and trouble ensues, the consumer does not know to whom to apply. The wiring contractor will probably tell him that the Corporation are to blame, while, on the other hand, they come direct to us, and in many cases we find the fault lies with the wiring contractor. We have no cases at present on the hire-purchase system, although, if requested, we spread the payment over five years. We get good prices for our work, so that other contractors cannot say that we cut their prices."

The profits made by the Bolton Corporation from this department are as follows :—

TABLE I.

Year	Profit from Electric Light Fitting Department
Ending March 25th, 1895	£428
„ 1896	£328
„ 1897	£656
„ 1898	£815

Leicester.—The profits made by the Corporation of Leicester from their wiring department are as follows :—

TABLE II.

Year	Profit from Electric Light Fitting Department
Half-year ending June 30th, 1896	£151
,, Dec. 31st, 1896	£231
,, June 30th, 1897	£183
,, Dec. 31st, 1897	£246
,, June 30th, 1898	£170

Vestry of Shoreditch.—The basis upon which wiring contracts are carried out is that of the actual cost of labour and material with 10 per cent. added for supervision. This 10 per cent., therefore, is practically the percentage of profit made on each installation fitted up by the Vestry. The department has not been in existence for a sufficient length of time to give any figures relating to the profits made.

City of Liverpool.—The method and basis of contracting is much the same as in Shoreditch. The reason that a town of such size as Liverpool has adopted this system is because the municipality purchased the undertaking from the Liverpool Electric Supply Company, the business of wiring contractors having been started with the Company. No published figures are available.

Hire-Purchase System.—None of the foregoing electricity supply undertakings have adopted the hire-purchase system. Such a system involves a large element of risk, and agreements would have to be

made with the owner or owners of the premises as well as the tenant. The possibilities of free-wiring, hire-purchase, and letting out on hire, are fully dealt with in other Sections under their respective headings.

Equipment and Management.—The equipment of this department must include the following :—

1. Stores, which must be distinct from works stores.

2. Staff, including estimating clerk, superintendent, storekeeper, carpenters, and wiremen.

The price of material varies with market fluctuations, but contract forms, tests, and specifications should be drawn up for all material which is bought in considerable quantities. The wages of a good storekeeper will be from 35s. to 40s. per week; for wiremen from 6½d. to 8d. per hour; and carpenters about 8d. per hour. Wages vary considerably in different parts of the country. The books necessary to keep in the department, and as tending to a perfect system of accounts, will include day book, ledger, contract and specification book, fittings invoice book, carriers' book (inwards and outwards), stores (inwards and outwards), cables stock book, lamps stock book, time book, and wages book. In addition to these it will be advisable to have a foreman's order book on the storekeeper, a stores order book, and a prime cost book. Examples are given in Fig. 1 of some of the books referred to. A fuller description of the method of store-keeping, and other headings for sets of books are given in Section V.

Methods and Systems of Wiring.—There are several methods of wiring, of which may be mentioned :—

1. Wires carried in wood casing.

2. Concentric lead-covered wire, in which the lead is used as a return conductor.

3. Twin lead-covered wires.

4. Wires carried in insulated iron pipes.

5. "Cosmos" patent wiring system.

6. Armoured wires.

A description of each method is given in special treatises on the subject.* In these volumes will also be found full details of the various systems in use, such as the distribution system, the tree system, and the three-wire system.

Capital.—The capital outlay required will necessarily vary under different conditions. At Bolton a capital of £1,000 forms the actual working capital, and it has, in fact, been found sufficient. This amount is specially appropriated from the moneys borrowed for electric lighting purposes generally, and is refunded annually, or that proportion of it which has been actually expended in wiring. This financial expedient is resorted to instead of obtaining advances from a bank, or of raising the money by levying a special rate for the purpose.

The present position of municipal authorities with regard to borrowing powers is explained in the following paragraph. The Local Government Board, in the exercise of its control, will not grant borrowing powers to a municipal authority for such a purpose as carrying on the business of wiring contractors, and this refusal necessarily involves all such other similar schemes as "free wiring," "hiring out of arc lamps and motors," &c. Power to raise capital for these objects would, however, be of immense value to the development of electricity undertakings, and it is to be hoped that Parliament will be petitioned to give further facilities in the direction of borrowing powers so as to include the schemes referred to.

Borrowing Powers. — The question raised in the preceding paragraph with reference to the borrowing powers for purposes of municipal wiring and hiring out of electric motors, &c., is not, so far as the author is aware, covered by any legal decision, and therefore at present depends upon the practice of the Local Government Board under the general Acts. Local authorities have, by virtue of the Electric Lighting Acts, and the Public Health Acts, power to borrow

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* "Electric Wiring," by Russell Rob. Electrician Printing and Publishing Co., London, E.C. Price 16s.

"Practical Electric Light Fitting," by F. C. Allsop. Electrician Printing and Publishing Co., London, E.C. Price 5s.

"The Electric Wiring and Fitting Details Book," by W. P. Maycock. Electrician Printing and Publishing Co., London, E.C. Price 2s. 6d.

money, with the consent of the Local Government Board, for the purposes of their undertaking generally; but one of the conditions imposed by Section 234 of the Public Health Act, 1875, is that the loan shall be available only for "permanent works." This term has been somewhat liberally construed by the Board, who, broadly speaking, consider that any work which may be expected to last for ten years or more is legitimately included under the denomination. Dynamo machines for generating the supply have therefore been treated as within the provisions; but loans for such objects as supplying "motors on hire," "wiring," &c., have not been allowed. Not, however, let it be again stated, that these loans have been definitely and distinctly ruled out on the ground that the work is not "permanent," but that the supply of motors, &c., does not fall within the general powers so far as they are governed by the Electric Lighting Acts and Provisional Orders.

Whether the decision of the Board as to the limits of these "general" powers is correct may probably be fairly open to question. The powers given by Section 10 of the Electric Lighting Act, 1882, are very wide, and might be construed, though not necessarily so, to include all works referred to in the preceding paragraph entitled "Capital."

In construing the words "meters and any fittings for the gas," which occur in the Gas Works Clauses Act, 1847, the Court of Appeal decided that the words included gas stoves, reversing the decision of a judge who had held the contrary. This decision, of course, enables municipal authorities to borrow money for the subsidiary business of letting on hire gas stoves and fittings.

A short time ago a protest was made by tradesmen at Leicester against the Local Authority undertaking wiring contracts and supplying fittings; and the matter formed the subject of discussion at a meeting of the Town Council, which was duly reported in the technical press. This discussion, however, significantly enough, did not indicate any intention on the part of the corporation to desist from trading in this

way. The matter appears now to await some legal decision upon the terms of Section 10 of the Electric Lighting Act, 1882. As, however, this appears to be a somewhat indefinite probability, the suggestion is made that powers could be sought from Parliament in each individual case, by inserting clauses when promoting a Municipal Parliamentary Bill. Examples of such clauses are as follows:—

1. *Power to supply Electric Motors and Fittings.*—The Corporation may provide, sell, let on hire, and fix, set up, alter, repair, and remove lamps, meters, motors, electric lines, fittings, apparatus and things for lighting and motive power, and for all other purposes for which electric energy can or may be used, or otherwise necessary or proper for the supply, distribution, consumption, or use of electric energy, and may provide all materials and do all works necessary or proper in that behalf, and may require and take such remuneration in money or such rents and charges for, and make such terms and conditions with respect to the sale, letting, fixing, setting up, altering, repairing, or removing of such lamps, meters, motors, electric lines, fittings, apparatus and things as aforesaid, and for securing (both as regards the consumer and third parties) their safety and return to the Corporation as the Corporation may think fit, or as may be agreed upon between them and the person to or for whom the same are sold, supplied, let, fixed, set up, altered, repaired, or removed.

2. *Conditions with respect to Electric Fittings.*—Any wires, apparatus, and fittings, in any building or premises supplied with electric energy by the Corporation, shall be subject to such regulations and conditions for securing the safety of the inhabitants and for the prevention of fire, as the Corporation may reasonably require.

SPECIMEN RULINGS FOR BOOKS FOR A WIRING DEPARTMENT.

STORES INWARD.

Date	Order No.	Description	Rate	£	s.	d.		Date	Order No.	Description	Rate	£	s.	d.

STORES OUTWARD.

Date	Reg. No.	Description	For work at	Rate	£	s.	d.		Date	Reg. No.	Description	For work at	Rate	£	s.	d.

CABLES. STOCK BOOK.

Date	Order No.	Quantity	Drum No.	Length	Description		Date	Reg. No.	Quantity	Drum No.	For work at

LAMPS. STOCK BOOK.

Date	Order No.	Quantity	Suppliers	Date	Reg. No.	To whom supplied		Date	Order No.	Quantity	Suppliers	Date	Reg. No.	To whom supplied

Fig. 1.

SPECIMEN RULINGS FOR BOOKS FOR A WIRING DEPARTMENT *(continued)*.

RAILWAYS BOOK.

Inwards.												Outwards.											
Date	Description	Senders	Carriers	T.	C.	Q.	lbs	Rate	£	s.	d.	Date	Description	Consignee	Carriers	T.	C.	Q.	lbs	Rate	£	s.	d.

STORES LEDGER.

Inwards.					Outwards.				
Date	Order No.	Quantity	Description	Suppliers	Date	Requisition No.	Quantity	Description	For work at

FITTINGS LEDGER.

Date	Quantity	Size or number of Article	Description	Rate	£	s.	d.	Date	Quantity	Size or number of Article	Description	Rate	£	s.	d.

INVOICE BOOK.

Date	Description	No.	Rate	Discounts			Date	Description	No.	Rate	Discounts		
				£	s.	d.					£	s.	d.

(It is now the usual practice to affix all Invoices received in a Guard Book, thus obviating the necessity for an Invoice Book proper.)

FIG. 1. *(continued)*.

SECTION III.

HOW TO CHARGE FOR ELECTRICAL ENERGY.

This subject is one of the most important with which an Electricity Committee has to deal. Indeed in many instances the method of charging adopted, apart from all other matters, has been responsible for either a profit-making or a money-losing concern. And yet the question is a many-sided one. It involves such phases as the time and duration of the demand, the purposes to which the electrical energy is applied, the nature of local requirements, and the possibility of securing a day load. The subject has been introduced at this stage because in subsequently dealing with motive power, tramways, street lighting, and other applications of electricity (which are often more extensive developments than ordinary house and shop lighting) it will be necessary to refer to the conditions which regulate the method of charging, and which, by consequence, either tend to encourage or to discourage the use of electricity for those purposes just enumerated.

The subject may be conveniently considered by dividing it into two well-defined sections, viz. :—

1. How the rate of charge for electricity is determined.

2. The various methods of charging for electricity and their respective relationship to certain local circumstances and conditions.

Before proceeding distinctly with the first section it will be as well to say that it is now a recognised fact that the applications of electrical energy are very many and very varied. In establishing an electric works it is no longer considered that its exclusive, or even its main purpose will be the supply of light. On the contrary, and as a matter of fact, in some towns attention is being given chiefly to the development of electric motive power, electric heating, and similar uses, by these means increasing the load factor and cheapening the supply. In a subsequent Section the variety of purposes to which electricity may be applied will be fully dealt with. Here it will suffice to say that whether used for lighting, motive power, or heating, the principles of charging for the energy supplied will be the same in all cases.

How the Rate of Charge for Electricity is Determined.—The charge for a supply of electrical energy should be, and is made, as a rule, in the same manner and upon a similar basis as that which decides the selling price of other commercial commodities. In the fewest words this may be stated to be the cost of production *plus* a reasonable percentage of profit. In the case of electricity it is by no means easy to ascertain what will be the actual cost of production until a works has been established and in operation for a couple of years. In smaller towns, with a population ranging, say, from 5,000 to 50,000, it may even be necessary for four or five years to elapse before the cost of production reaches a fairly constant figure. Where such uncertainty exists the practice usually adopted is to charge, in the first place, an arbitrary sum, which varies from 6d. to 8d. per unit. Whatever the price may be which is thus tentatively charged, it may be taken to represent the *average* cost per unit for one entire year. Experience already proves that, in ascertaining the costs of generation and supply of electricity, the average must be taken over at least a complete twelve months. The reason for this lies in the fact that the hours in which artificial light is required are many in the first and last three months of the year, and few in the intermediate months. The cost of production will therefore vary greatly, simply because the consumption varies from one period of

the year to another ; and unless an average annual charge were made, the selling price would fluctuate with almost every quarter of the year. This fact is mentioned incidentally here, but its importance will be seen when comparing side by side the various methods of charging ; it forms a distinct point of consideration outside and beyond other factors which make up the cost of production.

The cost of production is made up of two items—

1. The cost of generation.
2. The standing charges.

These may be sub-divided as follows :—

Cost of Generation.

1. Coal, coke, or other fuel.
2. Water.
3. Oil, waste, and similar items.

Standing Charges.

1. Salaries and wages.
2. Repairs and maintenance.
3. Rents, rates, and taxes.
4. Sinking fund or amortization of capital.
5. Interest on capital.
6. Depreciation.
7. Contingencies (office expenses, &c.).

By thus dividing the cost of production into its component parts it can be seen at a glance that the items comprising the "Cost of Generation" will increase in practically the same ratio as the number of electrical "units" generated—that is to say, if the quantity of electrical energy generated is increased two-fold, then the cost of generation is also increased two-fold. For the phrase "cost of generation" we may therefore substitute the term "unvarying charge," taking, of course, the Board of Trade unit as a basis. Thus, supposing the cost of generation

to be 1d. per unit, that figure will be unvarying, no matter how many or how few units are generated.

The "Standing Charges," however, affect the cost of production in exactly the very reverse way. The fewer the "units" generated the greater will be the *pro ratâ* cost *per unit.* This, of course, arises from the fact that to all intents and purposes the items under this head remain the same *in toto*, whether the units generated are few or many. Considered, however, relatively to the basis of charge, or the cost per unit, it will be seen that if the standing charges are calculated *as an average* over the number of units generated, then the rate per unit will vary in inverse proportion. Thus, supposing the rate per unit under Standing Charges to be 4d. for 100,000 units generated, then 200,000 units generated for the same standing charges would, of course, reduce the charge to 2d. For the words "Standing Charges" we may, therefore, substitute the term "Varying Charges." The two factors which make up the cost of production may thus be described by the alternative terms "Unvarying Charges" and "Varying Charges"; and assuming, for the sake of illustration, an arbitrary figure, say 7d., to be the total cost of production per unit, the respective charges will work out approximately in the following proportions:—

1½d.	Coal. Water. Oil, waste, &c.	Unvarying charges.
5d.	Salaries, &c. Repairs, &c. Rents, &c. Sinking fund. Interest. Depreciation, &c.	Varying charges.
½d.	Profit.	
7d.	Total cost of production.	

As a matter of fact some arbitrary figure must be taken in the

first instance of commencing the public supply of electricity, as it is not until the completion of the second or third year that the true maximum price can be ascertained. The maximum price per unit (say 7d., as in the preceding example) is now generally understood to be *that price which would cover the entire cost of production if the maximum demand was a constant and uniform rate of supply for one hour per day throughout the year.*

Upon this basis it is clear that if the units produced in any year represent exactly a daily average of one hour's running of the plant at full load, then the charge per unit will represent the maximum charge. For example, if 100,000 units represent the average daily hour's demand, and the cost of running the whole concern is £3,000 for the year, then the price per unit will be found to be just over 7d.

It has now been ascertained that the usual method of charging is based upon the assumption that all the items forming the cost of production should be entirely paid out of the first hour's daily average demand. If this is the case, it follows that, if the number of units sold in the twelve months exceed the number required for one hour's daily average, then the excess number of units will of course have cost only the generating costs to produce. This aspect of the case will, however, be dealt with under the next heading, where the various *methods* of charging for varying demands will be considered.

Table III. shows the hours per annum for maximum demands from 1,000 watts upwards, for a daily average of 1 to 24 hours.

The Various Methods of Charging for Electricity and their respective relationship to certain local circumstances and conditions.—The original and most simple method of charging for electrical energy is that of one uniform price. This was the system adopted in the first instance of electricity supply from central stations (following undoubtedly in this respect the method which the gas companies had raised as a precedent). The first step in the direction of alteration or modification, viz., that of giving rebates off the account for large consumptions of current, was only another instance of following in the wake of the gas companies'

methods. Neither of these methods, however, has been found to satisfactorily answer all the requirements in the case of electric light and

TABLE III.—*Board of Trade Units per Annum.*

Hrs. p. day	Watts 1,000	Watts 2,000	Watts 3,000	Watts 4,000	Watts 5,000	Watts 6,000	Watts 7,000	Watts 8,000	Watts 9,000	Watts 10,000
1	365	730	1,095	1,460	1,825	2,190	2,555	2,920	3,285	3,650
2	730	1,460	2,190	2,920	3,650	4,380	5,110	5,840	6,570	7,300
3	1,095	2,190	3,285	4,380	5,475	6,570	7,665	8,760	9,855	10,950
4	1,460	2,920	4,380	5,840	7,300	8,760	10,220	11,680	13,140	14,600
5	1,825	3,650	5,475	7,300	9,125	10,950	12,775	14,600	16,425	18,250
6	2,190	4,380	6,570	8,760	10,950	13,140	15,330	17,520	19,710	21,900
7	2,555	5,110	7,665	10,220	12,775	15,330	17,885	20,440	22,995	23,550
8	2,920	5,840	8,760	11,680	14,600	17,520	20,440	23,360	26,280	29,200
9	3,285	6,570	9,855	13,140	16,425	19,710	22,995	26,280	29,565	33,050
10	3,650	7,300	10,950	14,600	18,250	21,900	25,550	29,200	32,850	36,500
11	4,015	8,030	12,045	16,060	20,075	24,090	28,105	32,120	34,135	40,150
12	4,380	8,760	13,140	17,520	21,900	26,280	30,660	35,040	39,420	43,800
13	4,745	9,490	14,235	18,980	23,725	28,470	33,215	37,960	42,705	47,450
14	5,110	10,220	15,330	20,440	25,550	30,660	35,770	40,880	45,990	51,100
15	5,475	10,950	16,425	21,900	27,375	32,850	38,325	43,800	49,275	54,750
16	5,840	11,680	17,520	23,360	29,200	35,040	40,880	46,720	52,560	58,400
17	6,205	12,410	18,615	24,820	31,025	37,230	43,435	49,640	55,845	62,050
18	6,570	13,140	19,710	26,280	32,865	39,420	45,990	52,560	59,130	65,700
19	6,935	13,870	20,805	27,740	34,690	41,610	48,545	55,480	62,415	69,350
20	7,300	14,600	21,900	29,200	36,515	43,800	51,100	58,400	65,700	73,000
21	7,665	15,330	22,995	30,660	38,340	45,990	53,655	61,320	68,985	76,650
22	8,030	16,060	24,090	32,120	40,165	48,180	56,210	64,240	72,270	80,300
23	8,395	16,790	25,185	33,580	41,990	50,370	58,765	67,160	75,555	83,950
24	8,760	17,520	26,280	35,040	43,815	52,560	61,320	70,080	78,840	87,600

power charges. The primary reason for this is that no cheap and efficient means of storing electrical energy corresponding with the storage

of gas in gasometers is as yet possible. The consequence is that whereas in gas plant, the actual producing machinery and retorts may be in effective operation, making and storing continually, even during the non-lighting hours of the day, electric generating plant must be provided of sufficient capacity to meet the entire demand at the moment it is required. The expenses of production and the capital outlay have, therefore, in the case of gas, been only half that required for electric light supply, with the very natural consequence that the cost to the gas consumer has, in the majority of cases, remained in about the same ratio. If, for example, it is supposed that somewhere a charge of 6d. per unit obtains for electricity, then it has been found possible to sell the same illuminating power in gas at an equivalent of 3d. per unit or, say, two shillings per 1,000 cubic feet.

It has already been shown that the charge for electrical energy is based upon an average consumption of one hour daily per annum. Many consumers, it need scarcely be said, do not reach this average for their maximum demand, while on the other hand many will exceed it. It is this latter class of consumer whose average annual demand runs to two, three, four, or more hours per day, which, by comparison, becomes so much more profitable to the department. Taking by way of illustration the analysis of the costs of production given in the preceding section, it will be seen that the profit accruing from the one-hour consumer will be $\frac{1}{2}$d. per unit. In the case of the long-hour consumer, assuming that he also is charged at the uniform rate of 6d. per unit, the profit for the first hour's supply will be, of course, only $\frac{1}{2}$d. per unit, but for succeeding hours the profit will leap to $4\frac{1}{2}$d. Such a rate of profit is, of course, exceptionally large, and in the case of heavy accounts the customer would undoubtedly and necessarily find the electric light to be very expensive. There is, however, yet another class of consumer, already referred to, namely, the one whose average does not reach and sometimes falls far short of one hour per day. If the charge to him is also 6d. per unit, and that charge is the average charge of one hour's daily demand, it is clear that such a consumer, instead of

being profitable, entails an actual loss upon the department. Where a business is subserved by these three classes of consumers it is evident that the profitable consumer has to pay a high price per unit in order to make up the deficiency of the unprofitable consumer—a state of things which is at least very undesirable. To avoid such an anomaly recourse is had to differential rates of charge, a system which is based upon the average number of hours per day the maximum demand of each consumer respectively is used. As already stated, the reason is that machinery, plant, buildings, and to a certain extent wages and other expenses, increase in proportion to every additional lamp which is required to be supplied.

Table IV., giving examples of averages for demands of different classes, is compiled from actual averages of consumption of electricity by consumers on the supply mains of the Bradford Corporation.

The various methods of charging will now be considered.

One Uniform Price per Unit.—With the exception of the application of electricity to motive power it is quite possible that the average demand in some towns may be so considerably in excess of the one hour per day, and the number of short-hour consumers so insignificantly small, that a uniform price per unit may be both fair and reasonable. This is especially so where the supply has been many years in operation, and where the consumers are very numerous. The sufficient reason is that the variations over and under the mean price, which would be the actual charges to consumers under a rebate system, differ so slightly from the uniform price charged as to be negligible. Most rebate systems, as will be seen later, either entail additional and special apparatus on the consumers' premises or are expensive to the electricity department in having to keep special records and make special inspections. Such has been found to be the case in Edinburgh, where the uniform charge is 4d. per unit; in Bradford the uniform charge being 4½d. per unit; in Halifax the uniform charge being 5d. per unit; in Huddersfield the uniform charge being 6d. per unit; and in Portsmouth the uniform charge being 4½d. per unit.

TABLE IV.—*Lighting.*

Class of trade and business premises used for	Time per day Hr.	Min.	Class of trade and business premises used for	Time per day Hr.	Min.
Shops—			Fancy dealers	1	3
Miscellaneous trades	2*	...	Fish and game dealers ...	1	1
Auctioneers	3	34	Tailors and clothiers ...	1	...
Stuffs, cloths, &c....	3	16	Hosiers	...	58
Picture frame makers ...	2	58	Dairies	...	54
Restaurants	2	55	Hairdressers	...	52
Grocers	2	23	Watchmakers	...	50
Jewellers	2	23	Indiarubber goods	...	50
Stationers	2	17	Piano dealers	...	46
Chemists	2	16	Photographers	...	29
Mantle makers	2	11			
Pawnbrokers...	2	9	**Offices**—		
Confectioners	2	3	Corporation show room ...	2	25†
Furniture dealers	2	...	Poor rate offices	2	20
Boot makers	2	...	Coal merchants	2	10
Fruiterers	1	54	Accountants	1	51
Opticians and cutlers ...	1	31	Tramway company	1	43
Tea dealers	1	30	Telephone company	1	42
Drapers	1	29	Railway companies	1	26
Hatters	1	23	Banking companies	1	12
Butchers	1	21	School board	1	3
Tobacconists...	1	16	Consulting engineer	...	58
Dyers and cleaners	1	11	Mercantile...	...	57
Cycle dealers	1	11	Aniline merchant...	...	54
Ironmongers	1	9	United States Consul ...	...	50‡
Milliners and dressmakers ...	1	4	Solicitors	...	37

* Includes a number of small shopkeepers.
† For hiring electrical apparatus.
‡ United States Consulate Offices.

TABLE IV.—*Lighting (continued).*

Class of trade and business premises used for	Time per day		Class of trade and business premises used for	Time per day	
	Hr.	Min.		Hr.	Min.
Land agents	...	31	Stuffs and woollen goods ...	1	25
Brewers	...	30	Yarn merchants	1	6
Stock and share brokers...	...	29	Miscellaneous	1	2 *
Insurance	...	28	Makers-up and packers ...	...	59
Building societies	...	26	Merchants and agents... ...	...	49
Patent agents	...	25	Wool and noils	...	48
Architects	...	24	Leather merchants	...	23
Wool brokers	...	18	Millinery	...	20
Manufacturers	...	15			
Places of Worship	...	28	**Institutions**—		
			Public institutions	1	18
Professions—			Mechanics' Institute ...	3	39
Doctors and dentists ...	...	48	Institute for the Blind ...	1	40
Private houses	1	10	Friends' Provident Institution	1	20
Places of Amusement,			Church Institute	...	26
Theatres, &c.	2	10			
Public Arc Lamps	3	41	**Public Offices**—		
			Town Hall	2	50
Warehouses—			Free Libraries	2	25
Umbrella warehouse ...	2	57	Markets...	1	55
Paper merchants	2	1	Clubs and Billiard Rooms	5	6
Provision merchants ...	1	47	Hotels	2	...
Wine and spirit merchants	1	32			

* Includes a number of small warehousemen.

TABLE IV. *(continued).—Motive Power.*

Class of trade and business premises used for	Time per day		Class of trade and business premises used for	Time per day	
	Hr.	Min.		Hr.	Min.
Warehouses—			**Shops**—		
Miscellaneous businesses ...	1	30*	Stationers	1	42
Makers-up and packers ...	3	25	Opticians and cutlers ...	1	30
Wine and spirit merchants...	2	6	Restaurants	1	8
Corn and flour merchants	2	...	Miscellaneous trades ...	...	49
Millinery, &c.	1	56	Grocers	...	23
Wool and noils	...	37	Tobacconists	...	13
Stuffs and woollen goods ...	...	36	Confectioners	...	2
Provision merchants ...	...	33	**Hotels**	2	27
Mineral water manufacturers	...	17			
Yarn merchants	...	7	**Offices**—Insurance	...	26

* Includes a number of small tradesmen.

It must be distinctly understood that the above instances have reference only to charges for electricity supplied for lighting purposes. Incidentally it may here be observed with regard to charges for motive power purposes, that a lower uniform rate is sometimes charged, such as 2d. per unit at Edinburgh, and 2½d. per unit with rebates at Bradford. Each of these cities has a continuous-current system. In Bradford the demand indicator is used in connection with charges for motive power, and the scale of rebates will be given when dealing with that subject.

To revert to the charge for lighting. It is almost impossible that a uniform charge per unit should be either an equitable charge or commercially successful when a supply is first started in a town. The charge must of necessity be high, and hence, to any but the short-hour user, prohibitive. But after a few years, when private householders

become consumers in considerable numbers, the average demand of whom is usually between two and three hours per day per annum, it may be found not only possible, but more desirable, to reduce the uniform price to an economical figure, and to dispense with all systems of rebates.

For the effects upon the cost of production of electrical energy and the revenue from its sale, due to the extension of electricity mains into the outlying and residential districts of a town, the reader is referred to Section XI.

The Maximum Demand Indicator Method of Charging.—This method is based on the calculation that all the standing charges should be paid for in the price per unit charged for a daily average of one hour's maximum demand per year. It has been shown that this charge has been found from experience to be about 7d. per unit. The "maximum demand" is the heaviest load which the electricity works are called upon to supply during the year, and this usually occurs in December. For the sake of example we may assume the maximum load to be 500,000 watts, and if this were a steady demand for one hour only for each day during the year the total number of units generated would be $\frac{500,000 \times 365}{1,000} = 182,500$. The assumption here is that the works maximum demand is the *sum* of all the maximum demands of the consumers. Hence it follows that, if each of these maximum demands can be automatically ascertained and recorded, then the number of units used per annum is in itself in each instance an indication of the average number of hours per day during which that load had been required. By referring to Table No. III. it will be seen that a maximum demand of 1,000 watts (say 10 ampères × 100 volts), which is, of course, equivalent to one Board of Trade unit per hour, necessitates a consumption of 365 units per annum before the daily average is reached. Therefore 2,000 watts maximum demand necessitates 730 units being used, and so on in proportion. If, however, the consumption in any case falls short of the number of units which is required as the equivalent of a daily average

use of one hour, the consumer should be charged a proportionately higher price. He is, as a customer, altogether unprofitable on the present method of charging for electricity. As a matter of fact, it is not found convenient in practice to charge *too* high an initial price per unit, or to reduce the basis of time to less than one hour per day per annum.

If, on the other hand, the consumption is in excess of the number of units required as the equivalent of the one hour's daily average, then the charge for this excess would practically represent a clear profit to the department, excepting only the bare cost of generation. Thus, for a maximum demand of 1,000 watts and a consumption of 730 units per annum, we get a daily average of two hours' use. If the whole of these units be charged at 7d., assuming that to be an all-round and uniform charge, the profit would be somewhat as follows :—

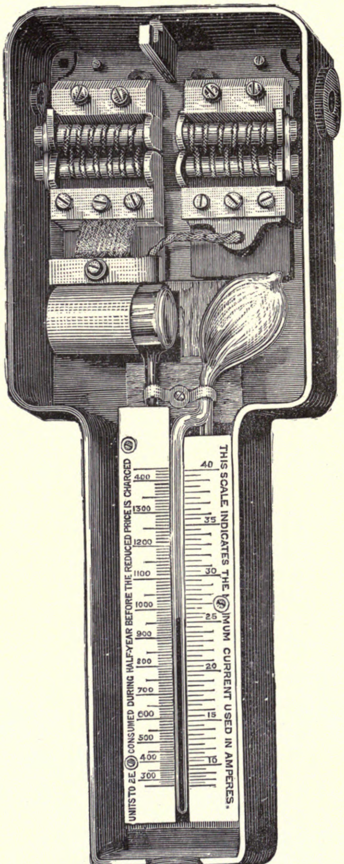
365 units, one hour's use	= ½d. profit per unit	=	£0	15	2½	=	7 per cent.
365 ,, two ,,	= 5d. ,, ,,	=	7	12	1	=	70 ,,
730	Total profit..................		£8	7	3½		

This point has been already explained under the heading "How the rate of charge for electricity is determined," and further elaboration of the matter need not therefore be repeated here.

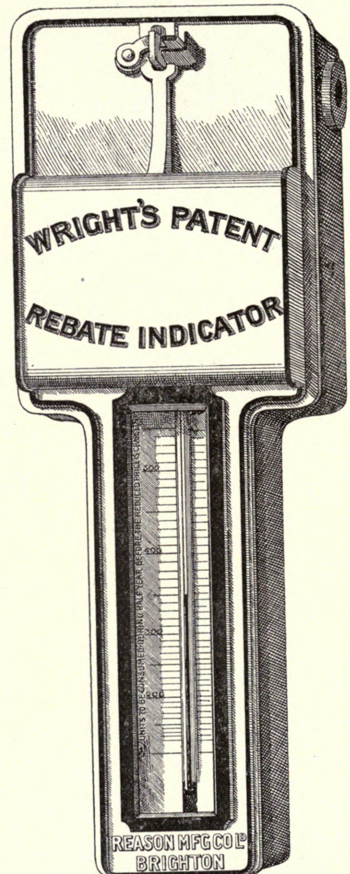
Under the system which we are now considering, the object is to charge such a price for all units exceeding the number required to make the one hour daily average, that the rate of PROFIT shall remain constant throughout, which in the instance just given would be 7 per cent., or ½d. per unit. It will, of course, be observed that the charge of 7d. for the first hour's consumption covers *all* charges—those of generation and those of supply. All extra current sold is produced at the cost of generation only, which in the preceding section we have assumed to be 1½d. per unit. This figure, together with the ½d. per unit profit added, gives the rate of 2d. per unit for all electricity used in excess of the first hour's daily average, and the differential rates ot charge thus become

7d. per unit for one hour's daily average demand per annum;
2d. per unit for all units consumed in excess of above.

MAXIMUM DEMAND INDICATOR.



OPEN.
Fig. 2.



CLOSED.
Fig. 3.

Such is the theoretical principle of the maximum demand method of charging; but its application in practice varies slightly according to the price charged for the first hour's supply, and also to the actual cost of generation. Table V. gives the rates found convenient in different localities, and also shows the average cost per unit to the consumer.

The instrument used to ascertain and record the maximum demand of each consumer, is known as "Wright's Demand Indicator," and is the invention of Mr. Arthur Wright, of Brighton. Illustrations are shown in Figures 2 and 3, representing the instrument "open" and "closed" respectively.

The indicator is really a thermal ammeter and is composed of two principal parts, viz.—a hermetically sealed tube containing air and a liquid, and a conductor of short length and of slightly higher resistance than copper. The action is as follows:—The passage of the current through the conductor, which surrounds one end of the hermetically sealed

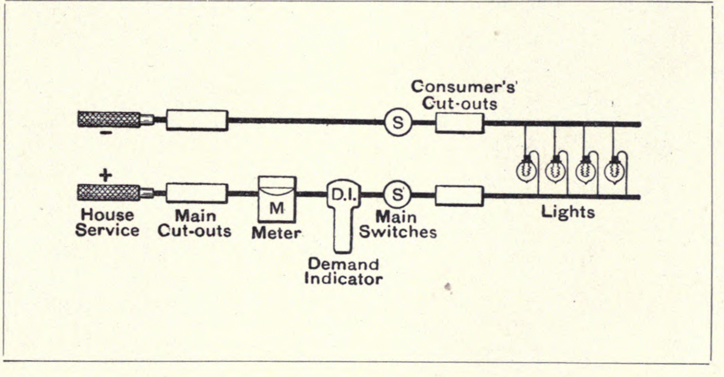


FIG. 4.

tube, causes a slight generation of heat, which expands the air inside the tube. The expanded air in its turn forces a portion of the liquid into an adjoining tube, where it remains permanently until the instrument is re-set by hand. The amount of liquid thus forced over from the one tube to the other, is proportionate to the current passing through the

conductor. The second tube is graduated or calibrated according to the particular scale of charging required. The maximum demand is read and noted in the Meter Reader's book every three or six months, and the Indicator is then re-set, *i.e.*, the liquid is returned to its original tube and the instrument sealed up. The position of the indicator in the wiring circuit is shown in the subjoined diagram (Fig. 4).

These indicators can be calibrated in Board of Trade units, and are direct reading. They are readily connected and require no attention.

TABLE V.

Tariff	Average cost of the unit (in pence) to various consumers							
	1 hr.	2 hr.	3 hr.	4 hr.	5 hr.	6 hr.	7 hr.	8 hr.
8d. for one hour, surplus at 2d. ...	8	5·0	4·0	3·5	3·2	3·0	2·86	2·75
8d. ,, ,, ,, 1½d....	8	4·75	3·66	3·12	2·8	2·58	2·42	2·31
8d. ,, ,, ,, 1d. ...	8	4·5	3·33	2·75	2·4	2·16	2·0	1·87
7d. ,, ,, ,, 2d. ...	7	4·5	3·66	3·25	3·0	2·83	2·71	2·62
7d. ,, ,, ,, 1½d....	7	4·25	3·33	2·87	2·6	2·41	2·28	2·18
7d. ,, ,, ,, 1d. ...	7	4·0	3·0	2·5	2·2	2·0	1·86	1·75
6d. ,, ,, ,, 3d. ...	6	4·5	4·0	3·75	3·6	3·5	3·42	3·37
6d. ,, ,, ,, 2d. ...	6	4·0	3·33	3·0	2·8	2·66	2·57	2·5
5d. for two hours, surplus at 2d. ...	5	5·0	4·0	3·5	3·2	3·0	2·85	2·75
5d. ,, ,, ,, 1½d....	5	5·0	3·83	3·25	2·9	2·66	2·5	2·37
5d. ,, ,, ,, 1d. ...	5	5·0	2·66	3·0	2·6	2·33	2·14	2·0

There is no mechanism to get out of order, but their use is not readily understood by the consumer. The price varies from 35s. upwards according to size.

We will now consider the effect of this method of charging, upon the consumer and upon the electricity works respectively. The experience of those towns, in which the method has been in use for an appreciable period, will also be given as an interesting contribution to the question. First of all with regard to the consumer. He can be sure that the price charged to him is the lowest at which the electricity department can sell, and that the rate of profit to the department remains the same (say 5 per cent. to 10 per cent.), whether he uses the current for a long or a short time, or in large or small quantities. But as will be seen from Table No. V., the selling price per unit is distinctly in favour and in encouragement of extended and continuous use. The electric light, if used for a long period per day, is the cheapest illuminant known, so far as production goes, but if only used for a very short period per day, it must, under present conditions, be necessarily one of the most expensive. At the present stage of electric lighting in this country, most consumers pay two lighting bills, one for the electric light, which they use in such places as shop windows, drawing rooms, &c., for a short time per day, and the other for gas, which, because it is cheaper, is used—and used for much longer periods—in all the less showy places, such as sitting-rooms, kitchens, bedrooms, backs of shops, &c. The consequences are that gas still retains the most profitable lights, viz., those used the longest; the consumer pays for light more than he ought, and does not get the best light where it is most important that he should. On the demand indicator system, however, every inducement is offered to the consumer to use the light freely and liberally, as *the longer they use it the cheaper the rate they pay for it.*

As an illustration of this fact Table VI. has been prepared, the figures being taken from consumers' accounts in Brighton, where this system of charging originated.

From this comprehensive table, the yearly cost of any one lamp used in either of the various classes of rooms and premises, can be determined, and also the saving which can be effected by replacing other forms of artificial light by electricity.

TABLE VI.—*Table showing how the Cost of Electricity Diminishes with the Lengthened Daily Use of the Light.*

Class of rooms and premises in which the lamps are used	Average number of hours the lamps are used per day	Total number of hours the lamps are used per annum	Usual time of extinguishing lamps lighted at dusk	Average rate charged per unit consumed during the year	Equivalent cost of gas used in ordinary burners per 1,000 cubic feet	Annual cost of electric and ordinary gas burners giving 8 c.p. — Electric lamp, including renewals	Annual cost of electric and ordinary gas burners giving 8 c.p. — Ordinary gas burner with gas at 2s. 9d. per 1,000 c. ft.	Amount saved per ann. on each 8 c.p. lamp by use of electricity, exclusive of saving in re-decorating, &c.	Time in which the cost of fitting up the electric light will be repaid by saving effected, due to its lesser cost and extreme cleanliness
				d.	s. d.	s. d.	s. d.	s. d.	
Offices, early closing shops, and occasionally used rooms	1	365	7 p.m.	7	4 1	5 10	3 11	...	...
Shop windows	2	730	8 ,,	About $4\frac{1}{4}$	2 6	8 1	7 10	...	...
Interiors of shops	3	1,095	9 ,,	,, $3\frac{1}{3}$	1 11	9 4	11 9	2 5	$2\frac{1}{2}$ years
Sitting-rooms, basements, halls, kitchens, and late closing shops	4	1,460	10 ,,	,, $2\frac{3}{4}$	1 8	11 1	15 9	4 8	2 ,,
Hotels, restaurants, and public houses	5	1,825	11 ,,	,, $2\frac{2}{3}$	1 6	12 10	19 8	6 10	19 months
Clubs and billiard rooms	6	2,190	12 ,,	,, $2\frac{1}{2}$	1 5	14 1	23 7	9 6	16 ,,
	7	2,555	1 a.m.	,, $2\frac{1}{4}$	1 4	15 10	27 6	11 8	14 ,,
	8	2,920	2 ,,	,, $2\frac{1}{5}$	1 $3\frac{1}{2}$	17 10	31 6	13 8	12 ,,
Outside lamps, basements, and dark business premises.	11	4,015	Dawn or used all day long	,, 2	1 2	22 4	43 3	20 11	9 ,,
	24	8,760	Continually used day and night	,, $1\frac{3}{4}$	1 0	42 7	94 2	51 7	5 ,,

The method of dealing with consumers' accounts in Brighton is as follows :—

1. In cases of three-wire services, one account only is rendered, and rental for one meter only is charged, the total of the two "demands" and the units consumed on each side, being taken when preparing the account.

2. In cases where a transfer of premises occurs during a half-year, each consumer, before any reduction is allowed, must use his demand 182½ hours in that portion of the half-year during which he occupies the premises, the new tenant receiving no benefit from his predecessor's use of the light.

3. In cases where a consumer removes from premises supplied, and takes a supply at other premises, no allowance for any electricity consumed in the first premises is made in the account for the second. Two separate accounts are rendered, and before any reduction is made the demand at each of the premises must be used 182½ hours in the respective portions of the half-year during which the premises are occupied.

4. When a consumer's installation is disconnected, or the lights discontinued, the demand indicator must be read.

5. If the reading is the only one obtained for that half-year, it will be taken as the consumer's demand for the purpose of preparing the account.

We will now briefly consider the effect which this system has upon the working of the department. One of the most prominent difficulties everywhere experienced in connection with electricity supply, is that of satisfying consumers—the small as well as the large—that they are being charged a fair rate, and that their accounts are correct. Consumers are very naturally constantly asking for a lower price, and in the past this demand has been frequently met by reducing the rates all round—an expedient which, as we have seen, means a loss on those consumers whose daily use of the light is very short. The maximum demand indicator method, by keeping up a

TABLE VII.

Town	Period during which Indicators have been in use at June, 1898.	Price charged per unit	Result of using Indicators	Remarks
Aberdeen ...	A little over 6 months.	6d. for first hour, 3d. afterwards, for lighting; 4d. for first hour, $1\frac{1}{2}$d. afterwards, for motors.	Not sufficient time in use to ascertain.	Had difficulty in getting consumers to understand the working of the system.
Bolton	18 months	6d. for first hour, 3d. afterwards...	Improved the output without increasing the peak of the load.	Every consumer is supplied with an indicator. Strongly recommends the adoption of this principle of charging.
Blackpool ...	About 16 months.	8d. for first hour, 2d. for each succeeding hour.	Increase of 20 per cent. in consumption from Sept. 1896, to Dec. 1897.	In favour of the system.
Bury	About 9 months.	6d. for first hour, 3d. afterwards, for lighting; $2\frac{1}{2}$d. for motive power without indicators.	Majority of consumers got good rebates on the last half-year's consumption.	Rather difficult to make consumers understand.
Burton-on-Trent	Only just started.	6d. for $1\frac{1}{2}$ hours, 3d. afterwards...	Too soon to notice any effect	No other method of charging.
Cardiff	2 years, ending December, 1897.	6d. for 2 hours, $3\frac{1}{2}$d. afterwards ...	No beneficial effects; consumers put on their lights on Saturday night only, with a total disregard of their indicator.	Difficulty in making consumers understand the system. Indicators are fixed on premises of all consumers who are charged by meter.
Cheltenham ...	About a year ...	6d. up to 375 units per ann. per kw. max. demand; $3\frac{3}{4}$d. over 1,500 units per ann. per kw. demanded; intermediate consumption *pro ratâ.*	Conduced to the spread of electric lighting in the town.	Indicators used for practically all consumers.
Coventry ...	2 years...	6d. for first 2 hours, $3\frac{1}{2}$d. afterwards.	Only 20 per cent. of total consumers obtain any rebate. No benefit in the least by use of indicators.	Customers do not understand system. Those who do not get rebates think they are paying for the current used by those who do.
Derby	For a short time.	6d. for $1\frac{1}{2}$ hours, 3d. afterwards ...	They are a great incentive for further demands for electricity and extensions.	Instruments very accurate. Take a good deal of extra time to read them at meter reading times.
Dewsbury ...	About 10 months.	6d. for first $1\frac{1}{2}$ hours, $3\frac{1}{2}$d. afterwards.	Of advantage, generally speaking, nothing definite.	Installed throughout the system.
Glasgow	12 months	6d. for first hour, 3d. afterwards, at 100 volts; 6d. for first hour, $2\frac{1}{2}$d. afterwards, at 200 volts.	No appreciable difference. Will probably be discontinued after May, 1898, on account of the perpetual worry and annoyance they cause.	Considerable outcry against demand indicator by consumers. Indicators adopted for every consumer.
Hampstead ...	Just commencing to fix them.	6d. for 2 hours, $2\frac{1}{2}$d. afterwards ...	No experience obtainable	... ...

Hanley	Only just started.	5d. for $1\frac{1}{2}$ hours, $2\frac{1}{2}$d. afterwards...	Too soon to notice any effect	Consumers have the option of this system or of an all-round price of 5d.
Hull...	18 months	6d. for first hour, 3d. afterwards...	Have answered the purpose for which the indicators were obtained.	Only used for consumers with more than 100 16 c.p. lamps. System optional. Ordinary charge, $5\frac{1}{2}$d. per unit.
Islington	Since the opening of station.	7d. for first hour, 6d. for second hour, 4d. for third and succeeding hours.	No information	Never supplied in any other way than by demand indicator system.
Kingston-on-Thames	3 years...	6d. for 2 hours, 4d. afterwards ...	No doubt it has been a benefit, but impossible to say in what direction.	No trouble with the new type of instruments.
Nottingham ...	About 10 months.	6d. for first hour, 4d. afterwards. An all-round price of 5d. per unit charged for places of public worship.	No results given, but charges of 4d. for second and succeeding hours reduced to 3d. in the case of theatres and music halls.	Nearly all consumers have indicators. No trouble experienced.
Shoreditch ...	Very short time.	No information	... ...	... ...
Southport ...	Over 2 years	7d. for first hour, 4d. for second hour, 2d. for third and succeeding hours.	For 11 months ending Feb. 1897, units sold per lamp connected = 8·9 units. For 11 months ending Feb. 1898, units sold per lamp connected = 10·6 units. Increase, 15 per cent.	Increased consumption per lamp connected attributed to use of demand indicators. Difficulty experienced in making consumers understand the system.
Southampton ...	16 months	6d. for $1\frac{1}{2}$ hours, $4\frac{1}{2}$d. afterwards	Improvement in load factor due to this system.	Considers $4\frac{1}{2}$d. per unit too high for second charge. Should be reduced to 2d.
Stafford	About $2\frac{1}{2}$ years (since commencement of supply).	7d. for first hour, 3d. afterwards...	Certainly gives a better load factor ...	Consumers are careful not to switch on at one time more lights than they actually require.
Sunderland ...	Introduced 1897.	5d. per unit first 2 hours in two winter quarters, 5d. per unit first hour in two summer quarters, $2\frac{1}{2}$d. for remainder of units consumed each quarter.	System has been beneficial. Load factor has increased by 3 per cent.	About three-quarters of total consumers supplied on this system.
Taunton	2 years	6d. for first hour, $3\frac{1}{2}$d. afterwards	Straightened out load curve after business premises are shut.	Not supplied to all consumers, but only to those who wish to be charged by that method.
Wakefield ...	About 6 months.	6d. for 2 hours, 4d. afterwards ..	Not sufficient time in use to ascertain.	Doubt if consumers will understand the system.
Walsall	9 months	6d. for $1\frac{1}{2}$ hours, 2d. afterwards ...	Have improved the demand and brought in consumers who otherwise would not have used electricity.	Instruments accurate and satisfactory.
Wolverhampton	About 6 months.	6d. for 2 hours, 3d. afterwards ...	No experience obtainable	Used throughout.

N.B.—The expression "6d. for 2 hours" means 6d. per Board of Trade unit for an average use of 2 hours daily per annum, or 730 hours.

high initial price, and by only giving rebates according to the larger use made of the supply, entirely obviates the necessity of continually considering the policy of reducing the charge per unit.

If all consumers used their maximum demand or full load for half an hour per day, it would cost approximately 1s. 3d. per kilowatt hour to the department, but if they used it for four hours per day the cost would only be 2¼d. per kilowatt hour.

By the adoption of this system of charging, the electrical engineer, and the electricity committee, minimise their responsibility, as it is almost impossible to make a loss on the undertaking, no reduction being made to the consumers until they have proved to be a source of profit.

A few consumers may object to getting no rebate; but, since the fact of their getting none proves they are not a source of profit, but a cause of loss, there is no need to trouble about them, and if they should cease to be consumers, they will not be a loss, as they will soon be replaced by more profitable ones.

It is a significant fact, that it is generally the half-hour consumers (who are a distinct source of loss to the department) who force expensive extensions on the station, for they almost invariably use the light only when the heaviest load is on; and in many towns, if they could be eliminated altogether, the loss in revenue would be small compared with the increased annual charges necessary to provide for supplying them.

The results of the adoption of this system in certain towns is set forth in Table VII.

From this table it will be seen that considerable difficulty has been experienced in almost every one of the towns, in getting consumers to understand this system of charging. Probably the majority of consumers never would understand it, because they know nothing whatever of the conditions of generating and supplying electricity. This, however, is no argument against the adoption of this system, and the fact that the *rate of profit* is practically uniform for all

classes of consumers, is a great feature in its favour. In some of the instances in Table VII., it will be observed the rate of profit does not appear to be a constant factor, as it ought to be. If we take as examples Cardiff, Coventry, Hampstead, Islington, Kingston-on-Thames, Southport, Wakefield, and Wolverhampton, we find the charge is practically 6d. for two hours, and 2d. to 4d. afterwards, which is, of course, equivalent to a charge of 1s. per unit for an average of one hour a day per year. This seems to be an excessive charge, and more than should be necessary to cover the entire costs of production. If, however, the production costs are entirely paid in the foregoing charge for two hours per day, then further charges of 2d., 3d., and 4d., appear exceptionally heavy. The chief value of this demand indicator method of charging lies essentially in the fact that it affords the opportunity of including all the standing charges in the rate per unit for the first hour's daily demand. The subsequent charges should undoubtedly be only a little over the cost of generation. While there is no objection to charging 4d. or 5d. a unit for the first two hours, and, say 2d. afterwards, it would be preferable by far, and for reasons already explained, to charge 6d., 7d., 8d., or 10d. for the first hour, and 2d. or less afterwards.

The Time-Switch Method of Charging.—This method of charging is very similar to that just described. It is based upon the same principles, viz. :—that at the time of maximum demand upon the generating plant, a higher price should be charged than at other times. It differs, however, in several important respects, which it will be well to carefully consider. The apparatus which gives its name to the method consists of a clock, which may be operated by a spring and wheel escapement, or by a spring and pendulum escapement, or by electricity supplied from a battery or from the mains. The clock actuates a switch, which, in its turn, controls a shunt circuit of a meter or a second meter circuit. In thus controlling a secondary or subsidiary circuit, the switch splits up or divides the current, at certain times of the day, into two paths, so that the registration takes place

on two separate meters, or a certain proportion on one meter, the remainder not being registered at all.

The time of the day during which it is necessary to register the whole of the current used, is the time when the maximum demand is made upon the electricity works, and which, of course, varies according to the period of the year. From January to March it is usually from 4 p.m. to 7 p.m., from April to June from 6 p.m. to 9 p.m., from July to September from 7 p.m. to 10 p.m., and from October to December from 4 p.m. to 7 p.m. During the entire remainder of the twenty-four hours, the plant is very largely standing idle, and it is during these two periods respectively, that the different rates of charging are automatically recorded by the time-switch. Thus, if the maximum demand at the electricity works occurs for three months daily from 5 p.m. to 6 p.m., then the meter or meters will register for that hour at the rate of, say 7d. per unit, and at every other time of the day at, say 2d. per unit or other pre-determined rates of charging.

The manner of accomplishing this differential method of charging by the time-switch, is shown in the accompanying diagram (Fig. 5). The diagram shows the connections as applied to a watt-meter, and it will be seen that the alteration in the registration of the meter, is effected by altering the ampère-turns in the armature by varying the added resistance in the same ratios as the rates to be charged. Where only one meter is used, the whole of the energy consumed is registered during the high-rate period, but only a proportion is registered during the low-rate period.

On referring to the diagram, it will be seen, that the switching over from one rate to the other in the system we are describing, is done by means of the switch K, which is rotated by means of a clock which makes one complete revolution in twenty-four hours. The indicator is placed inside the case of the clock, and a window is provided below the dial, enabling the consumer to see at a glance, the rate he is being charged at any time.

The only objection that has been urged against this system, is

that the clocks may stop (their accuracy as timekeepers is comparatively unimportant), and to avoid inconvenience from their doing so, an automatic cut-off is provided, which throws the indicator over to the high-rate immediately the clock stops, and it is reasonable to assume that the consumer will communicate with the works, immediately he discovers that he is being charged 7d. per unit during the 2d. period. The clock is also provided with a set of gear wheels and a dial, showing the number of days the clock has been going, and consequently how long it has been stopped, so that the stopping of the clock, which, after all, is not likely to happen often, but which must be provided for, does not create any difficulty or introduce any complication.

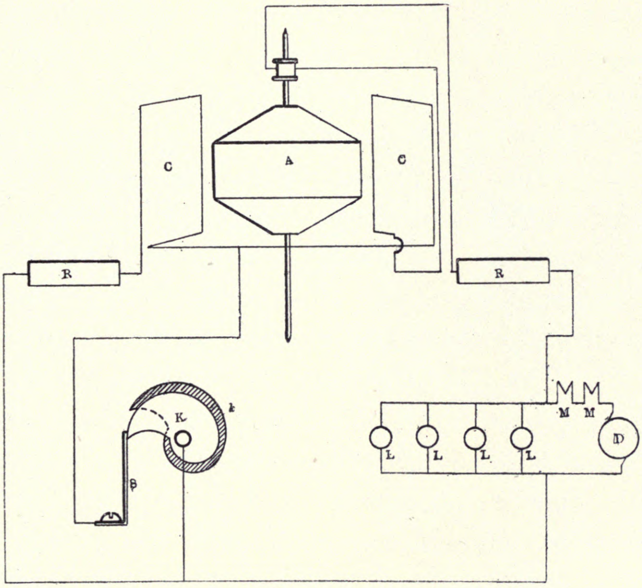


FIG. 5.—SHUNT-TYPE METER.

In some cases it may be found necessary for statistical purposes, to register the current consumed during the different periods independently, and it will then be necessary to fix two meters, and so arrange the connections (in the case of watt-meters), that one armature only is

energised at a time, but in the case of ampère-hour meters, the desired result may be obtained by connecting them both in series, and cutting one out altogether during the low rate, and taking the sum of both readings during heavy loads.

The object of this method of charging is very clearly indicated in the simple and definite application of the principle in the apparatus employed. This method makes no record of the consumers' maximum demand, and in fact takes no notice of it as such, but charges one price for electricity during certain hours of the day and another price at other hours, irrespective of what the actual maximum demand may be. The consumer, therefore, cannot be in doubt at any time as to what price he is actually called upon to pay for his current. With the demand indicator method, this uncertainty becomes the principal element of difficulty, as may be seen on reference to the experiences given in Table VII. Another important advantage gained by the adoption of the time-switch lies in the fact that, unlike the maximum demand indicator, it does not assume that the maximum demands made by the consumers are simultaneous. With the demand indicator, which embodies similar principles, each consumer is given a discount on the basis of his maximum demand, although that demand in the case of one consumer may be made at eight o'clock in the morning, and in the case of another at eight o'clock in the evening. Both these consumers are granted discounts on the same basis, and to precisely the same extent, if their maximum demands and total consumption are the same, notwithstanding the important difference relatively to the supply works that the morning maximum demand does not affect the standing charges at all, while the evening demand does. The former tends to reduce the total cost of production all round, while the latter may raise it.

The time-switch method has very many features in favour of its adoption. It is cheap and simple to fix, and provides an absolutely equitable system of discounts, whereby every individual's discount is automatically based on the amount of profit included in his total bill. Time-switches have been adopted by the Bristol Corporation Electricity

Department, but as the method has only recently been introduced, it is not possible to give any details in connection with their experience. Other towns are also contemplating the same system of charging.

The Manchester Method of Charging.—The City of Manchester, which is unique in the system employed for the distribution of electrical energy, from the fact that it is the only city or town in which the five-wire system is used, is also unique in the methods adopted for charging for the current. The one has no special relationship to the other however, and hence it may be taken for granted, that the nature of the supply, and the effect of the cost of generation and production upon the charge per unit, is the same as in other similar undertakings. The object of the methods of charging (which are two alternative methods) is to charge that price which will cover the entire costs of production together with a certain rate of net profit for an assumed maximum demand of one hour per day per annum. (See Table III.) These methods are—

1. An uniform charge of 6d. per unit.
2. A fixed charge per annum per lamp installed, *plus* a charge per unit as registered on the meter.

In the first method, there is nothing exceptional in Manchester as compared with any other place which simply charges one uniform rate per unit. The reading of the meter is taken, and the full price is charged, irrespective of the period of the twenty-four hours during which the supply may have been required. This method is no doubt the simplest and the best in a very large number of instances, as will readily be seen upon reference to Table IV., giving a list of average demands of daily use. The consumer, however, if he has any reason to believe that his daily average use will exceed two hours, has the option of choosing the second method of being charged, but he must rest content with his choice for at least twelve months. Should he elect to be charged by the second method, and his daily average use should fall short of one hour, it will be seen that his rate per unit will exceed that of the uniform rate of 6d,

In the second method, the object is to make each consumer pay in proportion to the cost of supplying him with current. To effect this, the consumer is charged a fixed amount, based upon the number of lamps installed. The charge is 4s. per 16-c.p. 66-watt lamp per quarter, or 16s. per annum, or, what is the same thing, a fixed charge of £3 per quarter per unit, or £12 per annum. In addition to these fixed charges, which are enforced whether the lamps are used or not, a further charge of 2d. per unit is made, according to the registration of the meter. In order to properly understand the difference between these first and second methods of charging, it will be advisable to consider them both together by the aid of hypothetical cases. We will, therefore, give a few examples, and at the same time show the various modifications which are adopted by the Corporation of Manchester to meet peculiar conditions of electric lighting and electric motive power.

Let us then, for example, assume an installation of 50 16-c.p. lamps and 10 32-c.p. lamps. The equivalent of these, for the purposes of the fixed charge rate, would be 70 16-c.p. lamps; 70 lamps at 16s. = £56 fixed charge per annum, or 70 66-watt lamps = 4,620 watts = 4·6 units at £12 per unit = £56 (approximately) per annum.

Taking the above example, and assuming that the consumer uses all his lamps for one hour per day for 365 days, his account for the year would be as follows:—

Fixed charge per annum	£56
Meter charge at 2d. per unit for (4·6 × 365) = 1,680 units ...	14
Total...	£70

Charged according to the other method in vogue in Manchester—viz., that of a uniform charge of 6d. per unit, the above installation would have incurred an account for the year represented by 1,680 units at 6d. = £42.

We have given the foregoing instance as an example of each of the two methods for an average consumption not exceeding 365 hours

per annum. It is clear from the saving of £28 on the account, by adopting the uniform rate of 6d. per unit, that the fixed charge method and 2d. per unit has been devised solely to meet the requirements of, and to benefit the long-hour user. Had this particular installation been in use for a much longer average per day, say four hours, the charges by the two methods respectively would be as under :—

First Method { Fixed charge per annum £56
Meter charge at 2d. per unit for (4·6 × 365 × 4) = 6,720 units ... ... £56—£112

Second Method, 6,720 units at 6d. £168

In this case the uniform charge is dearer than the fixed charge by £56. Where then may we draw the line, at which it becomes of advantage to the consumer to elect to be charged according to the former method? It will be seen that if the number falls below* 720 hours per annum then the uniform rate of charging is the cheaper method, and *vice versâ.* The following Table VIII. shows the corresponding price per unit for certain annual demands :—

TABLE VIII.

Number of hours per annum during which electric light is used	Corresponding price per unit in pence	Number of hours per annum during which electric light is used	Corresponding price per unit in pence
480	8	960	5
523	7½	1,160	4½
576	7	1,440	4
640	6½	1,920	3½
720	6	2,880	3
823	5½	5,760	2½

* If the price charged per unit is at any time reduced below 2d., or the fixed charge below the figures given herein, then the hours per annum given above will also be reduced.

Table IX. shows the average cost per unit with the fixed method of charge, the rates being £3 per quarter per unit of maximum demand and the meter charge 2d. per unit consumed.

TABLE IX.

Hours of burning per annum	Average price per unit in pence	Hours of burning per annum	Average price per unit in pence
100	30·8	2,500	3·15
200	16·4	3,000	2·96
300	11·6	3,500	2·82
400	9·2	4,000	2·72
500	7·8	4,500	2·64
600	6·8	5,000	2·58
700	6·1	5,500	2·52
800	5·6	6,000	2·48
900	5·2	6,500	2·44
1,000	4·9	7,000	2·41
1,200	4·4	7,500	2·38
1,400	4·1	8,000	2·36
1,600	3·8	8,500	2·33
1,800	3·6	(No. of hrs. in 1 yr.)	
2,000	3·4	8,760	2·33

The practical working of the system is explained as follows: When ordinary 66-watt lamps are used, the number of lamps and their respective candle-powers are ascertained. The equivalent number of lamps of 16-c.p. is then calculated, and the fixed charge based upon it. When high-efficiency lamps are used, an ammeter is placed in the

house circuit, and the whole of the lamps are switched on. The maximum current is then multiplied by the voltage of supply, and the fixed charge based on the £12 per annum per unit of maximum current. In the case of motors and arc lamps, the maximum current required is always ascertained, and if the amount of current is found to be more than that at which the apparatus is rated, the fixed charge is increased in proportion.

There are one or two serious difficulties, however, in placing absolute reliance upon the information obtained by the preceding methods. There is, of course, the possibility of the number of lamps being increased without the knowledge of the Corporation, in which case each additional lamp is using current at the very low price of 2d. per unit. Again, the consumer finds, perhaps, that he has not sufficient light, and to meet his requirements simply substitutes a higher candle-power lamp for the existing one, with the same result as in the case of increasing the number of his lamps. It may be urged on the other hand, that the consumer may find his account for electricity too heavy, and so replace existing lamps by those of lower candle-power, and in consequence, the fixed charge becomes too high. This possibility, however, is not very frequently met with.

In order to minimise such contingencies as these, the following precautions are taken :—Electrical inspectors are employed whose business it is to visit consumers' premises with sufficient frequency to count the number of lamps, and at the same time to ascertain the candle-power of each. This, of course, is an expense ; but as the inspection serves other purposes as well, it is not so heavy as appears at first sight. For instance, the counting of the lamps, &c., is also really necessary in order to keep the current equally distributed over the five-wire system, and for this object alone every lamp is taken into account at Manchester. Other duties undertaken by these inspectors are the cleaning of boxes, changing fuses, meter testing, insulation testing, examining sealed apparatus, tightening contacts, &c.

Another method of ascertaining the maximum current for the

purpose of the fixed charge is by using demand indicators. They are, however, employed only in a comparatively few cases where considerable difficulty is likely to arise in correctly counting the number of lamps, such as in large hotels.

Other Methods of Charging.—In addition to the systems already described, there are others which are modifications of one or other of them. No useful purpose will be served by any further description, as the reasons for their adoption could not be sufficiently explained without a knowledge of the respective local circumstances and conditions. These other systems may, however, be summarised briefly as follows :—

(a) "Daylight" circuits at reduced rates.

(b) Motive-power and cooking at reduced rates.

(c) Andrew's modification of the maximum demand indicator method, as used at Hastings.

(d) The sliding scale, as originally adopted at Ayr.

(e) Differential rates, based on time of demand, as at Norwich.

(f) A few other methods adopted by some of the London electric lighting companies ; and

(g) A somewhat complicated method at Glasgow, consequent upon the change-over from a supply pressure of 100 volts to that of 200 or 250 volts. This method was adopted by the Glasgow Corporation on August 4, 1898, and is as follows :—(1) That all consumers of current, whether for lighting or motive power during the year which commenced on 1st June 1898, should have the option of continuing to be charged in accordance with the demand indicator system, which has been in operation for the last two years, or of being charged a fixed rate per annum for each 8 candle-power lamp or its equivalent fitted up in their premises—spreading this charge uniformly over each month in the year—with an additional rate of so much per unit (over and above the fixed charge) for each unit consumed as recorded on the meter ; (2) that, in the case of the demand indicator system, the initial charge should remain at 6d. per unit for the first hour, with 2½d. per unit thereafter to the 100-volt consumers, and 2d. per unit thereafter to the 200-volt and 250-volt

consumers; (3) that, under the alternative method of charging to be given to consumers, the fixed rate should be 4s. 6d. per lamp per annum, with $2\frac{1}{2}$d. per unit additional to the 100-volt consumers, and 2d. per unit to the 200-volt and 250-volt consumers; and (4) that, to all consumers who take a supply for more than the equivalent of seven hours each day at full load for twelve months, the initial charge in the case of the demand indicator system, and the fixed charge of 4s. 6d. per 8 candle-power lamp in the case of the alternative system, should be remitted.

In concluding this section it may be stated that each method of charging seeks to combine simplicity with equity. That some fall far short of the object desired there can be no doubt, while the simplest method is not necessarily the most equitable. It is also clear that finality is by no means reached, and the problem but incompletely solved as regards this subject.

SECTION IV.

ELECTRIC MOTIVE POWER.

In this section it is proposed to deal with electric motors, their application to a great variety of purposes, their effect upon the output and costs of the generating station in establishing a "day load," and their advantages over other forms of motive power.

The figures and other data which are given in this section will only apply to continuous-current electric motors, and in all cases only actual working results are recorded. No theoretical values or deductions are given, as the data are intended to be of a reliable and practical character.

Application and Working Cost.—Electric motors may be applied to any purpose to which other forms of power may be applied, and with considerable advantages over most of them. These advantages will be separately and fully dealt with further on, but one of the most prominent may be mentioned here, viz., the fact that they can be coupled direct to any single piece of machinery or apparatus which requires a driving power. Even where it is not possible or convenient to couple the shaft or spindle of the motor directly to its work, the necessary intermediate gearing can be arranged in such a manner as to minimise the losses in transmission. It is not proposed to go into the question here with

regard to the varied designs of motors or to discuss the description and efficiency of different forms of gearing. These phases of the subject have been dealt with in detail and exhaustively as a special subject,* and the engineer or technical reader is referred to such special treatises. We will confine the treatment of the subject to the distinctive features of electric motors and the cost of running compared with other forms of motors, assuming that where power of any description is required electric motors are equally applicable. The general purposes to which electric motors may be applied are very much the same in all towns; but, in addition to such general purposes, these motors might often be utilised in connection with special industries or manufactures which almost every town possesses. It should not be a matter of great difficulty to ascertain what is the power required and the cost of working according to the present methods for such processes, and the corporation electrical engineer can readily say whether it would be both cheaper to the customer, and advantageous to the electricity department to substitute electric motors. It is, of course, impossible to deal exhaustively with these many and diversified purposes to which electric motors may be applied, but a few of the more general uses may be profitably considered. These may be enumerated as follows:—

Electric traction, passenger lifts, goods hoists, warehouse cranes, kitchen lifts, printing machinery, hair-brushing machinery, cloth-folding and cuttling machinery, press pumps, blowers for fans for foundry work, ventilating fans, pumping, turning (lathe work), general engineering purposes, wood working machinery, ærated water machinery, cutlery making and grinding, hotel kitchen purposes, wheat grinding, sausage and meat chopping, coffee grinding, electric signs, tobacco cutting, plate polishing, cabinet making, beer bottling, boot polishing machinery, laundry machinery, sewing machines.

The power required and the cost of working some of the apparatus mentioned in the preceding list will now be considered:—

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* "Motive Power and Gearing," by E. Tremlett Carter. The Electrician Printing and Publishing Co., London, E.C.
"May's Belting Table." The Electrician Printing and Publishing Co., London, E.C.

TABLE X.—*List of the Approximate Horse-Power required for Various Purposes.*

ÆRATED WATER, &c., PLANT.

Bottle-washing Machine—Capacity 1,000 doz. per day	$1\frac{1}{2}$ H.P.
Double Bottle-washing Machine—Capacity 100 doz. per hour	$1\frac{1}{2}$,,
Filling and Corking Apparatus—Capacity 100 doz. per hour...	$\frac{1}{2}$,,
Soda-water Machines—Producing capacity 700 doz. per day	$\frac{1}{2}$,,
Producing capacity 1,200 doz. per day	1 ,,
Producing capacity 50,000 doz. per day	3 ,,

AUTOMATIC ELECTRIC SIGNS.

Sign consisting of 78 8 c.p. Lamps	$\frac{1}{12}$ HP.

BOOKBINDING AND BOX-MAKING PLANT.

Box-corner Cutting Machines	3 to 5 H.P.
Combined Scoring, Bending, and Grooving Machines—31 in. to 50 in. between side gauges	1 to 5 ,,
14 in. Board-scoring Machine	$\frac{1}{2}$ to 2 ,,
26 in. ,, ,, ...	1 to 3 ,,
42 in. ,, ,, ...	2 to 5 ,,
Wire-stitching and Binding Machines—To stitch up to $\frac{1}{2}$ in. thick	$\frac{1}{2}$ to 6 ,,

BRUSH-MAKING MACHINERY.

(See Wood-working Machinery.)

CARPET-BEATING PLANT.

Beater—Taking carpet 6 yds. wide	6 H.P.
Tumbler Carpet Beater—To beat 120 yds.	6 ,,
Willowing Machine—For teasing cotton and woollen flocks	6 ,,

CYCLE-MAKING AND REPAIRING.

Automatic Capstan Lathe	1 H.P.

DENTAL SURGERY APPLIANCES.

Dental Engines	$\frac{1}{8}$ to $\frac{1}{2}$ H.P.

ELECTRIC TRACTION.

Electric Traction—Per car	10 to 60 H.P.

TABLE X. *(continued).*

FOUNDERS.

Blower—To pass 2,300 cub. ft. of air per minute, at 1 lb. pressure per sq. in. ...	20 H.P.
Five Ton Travelling Crane ... ... (single motor)	$4\frac{1}{2}$,,
Sand-mixing Plant	3 ,,
Three Emery Wheels, Two Shaking Boxes, Drilling Machine, and Grindstone ...	3 ,,

LAUNDRY MACHINERY.

Box Mangle	$\frac{1}{4}$ to $\frac{1}{2}$ H.P.
Hydro-extractor—26 in. to 32 in.	2 to 3 ,,
Ironing Machine—Width of ironing roller, 100 in.	$1\frac{1}{2}$ to 2 ,,
Wringing Machines	$\frac{3}{4}$ to $2\frac{1}{2}$,,

LETTERPRESS AND LITHOGRAPHIC PRINTING PLANT.

Guillotine Cutting Machines—26 in. to 32 in. wide	$\frac{3}{4}$ H.P.
,, ,, 38 in. to 44 in. wide	1 ,,
Ink Grinding Mills—Rolls 12 in. × 8 in.	3 ,,
Rolls 18 in. × 10 in.	4 ,,
Rolls 24 in. × 12 in.	5 ,,
Letterpress Cylinder Machines—Demy and double crown	1 ,,
Double demy and quad crown	$1\frac{1}{2}$,,
Linotype (type setting) Machines	$\frac{1}{2}$,,
Lithographic Machines—Demy, double demy, quad royal	1 to 4 ,,
Paper Glazing Machines—To roll 27 in. to 36 in. wide	3 to 5 ,,
Platen Machines—Foolscap folio, crown folio, and demy folio	$\frac{1}{2}$ to 7 ,,

METAL-WORKING MACHINERY.

Amateur's Lathe	$\frac{1}{2}$ to 1 H.P.
Drilling Machine—For up to 2 in. holes	2 to 3 ,,
Engineer's Grindstone—4 ft. diam.	$\frac{1}{2}$ to 1 ,,
6 ft. Planing Machine	2 to 3 ,,
Sliding Surface and Screw-cutting Lathe—7 in. centres	1 to $1\frac{1}{2}$,,

PAPER-MAKING PLANT.

Glazing Calender—Paper 80 in. wide	15 to 30 H.P.
Paper Machines	25 to 30 ,,
Rag Engines	15 to 35 ,,
Rotary Cutting Machine...	1 to 2 ,,

TABLE X. *(continued).*

PACKING-CASE MAKING MACHINERY.

(See Wood-working Machinery.)

UMBRELLA AND STICK-MAKING PLANT.

Eight Lathes and Eight Sewing Machines (combined)	$1\frac{1}{2}$ H.P.

VENTILATING FANS.

Portable Desk, Ventilating Fans, and Motor (combined)—Suitable for offices, &c.	$\frac{1}{12}$ H.P.
To move 1,000 to 1,500 cubic feet of air per minute	$\frac{1}{8}$ to $\frac{1}{4}$,,
,, 2,000 to 3,000 ,, ,, ...	$\frac{1}{4}$ to $\frac{1}{2}$,,
,, 3,000 to 6,000 ,, ,, ...	$\frac{1}{2}$ to $\frac{3}{4}$,,
,, 5,000 to 9,000 ,, ,, ...	$\frac{5}{8}$ to $1\frac{1}{4}$,,
,, 20,000 to 45,000 ,, ,, ...	$1\frac{1}{2}$ to $3\frac{1}{2}$,,

WOOD-WORKING MACHINERY.

Band Saw Machine—To saw 16 in. to 22 in. deep	$\frac{1}{2}$ to 1 H.P.
Combined Band Saw Machine and Saw Bench—To saw 9 in. deep	4 to 5 ,,
Combined Planing and Moulding Machine, for flooring and match boarding—	
For planks up to 9 in. wide by 3 in. thick	5 to 6 ,,
For planks up to 16 in. wide by 6 in. thick	7 to 8 ,,
Combined Roller-feed Timber and Deal Frames—To saw logs 16 in. diameter by 25 ft. long...	3 to 4 ,,
Combined Roller-feed Timber and Deal Frames—To saw logs 42 in. diameter by 45 ft. long	12 to 14 ,,
Dovetailing Machines—To dovetail up to 15 in. to 36 in. wide by $1\frac{1}{4}$ in. thick ...	$\frac{1}{4}$ to 1 ,,
Four Cutter General Joiner—To saw 9 in deep, to plane 9 in. wide by 3 in. thick	5 to 6 ,,
Fret Saw Machine—To cut up to 8 in. deep	1 to $1\frac{1}{2}$,,
Joiners' and Box Makers' Cross-cut Saw Bench—To cross-cut 24 in. wide by 6 in. thick	$\frac{1}{2}$ to 1 ,,
Log-sawing Machines—For trees up to 4 ft. diameter	4 to 5 ,,
For trees up to 6 ft. diameter	6 to 7 ,,
Moulding-iron Grinders, Saw-sharpening Machines, and Sand-and-papering Machines...	$\frac{1}{2}$ to 1 ,,
Pattern Makers' Lathe	2 to 3 ,,

TABLE X. *(continued).*

WOOD-WORKING MACHINERY *(continued).*

Rack Circular Saw Bench—Saws up to 42 in. diameter, to saw 16 in. deep...	5 to 6 H.P.
Saws up to 78 in. diameter, to saw 33 in. deep	...14 to 16 „
Rack-feed Timber Frames—Logs 16 in. diameter by 25 ft. long	4 to 5 „
Logs 36 in. diameter by 40 ft. long ...	..10 to 12 „
Rip Saw—Cutting speed 9,000 ft. per minute, ripping hard wood, 6 in. thick at 10 ft. per minute	... 15 „
Roller-feed Timber Frames—For logs 20 in. diameter by 25 ft. long ...	... 5 to 6 „
For logs 30 in. diameter by 35 ft. long... ...	8 to 9 „
Rounding Machine—To round up to 1½ in. diameter	... ½ to 1 „
To round up to 3 in. diameter	1 to 1½ „
Tenoning Machine	... 1 to 3 „

MISCELLANEOUS TRADES.

Automatic Powder Weighing Machine	⅛ to ½ H.P.
Boot Polishing Machines	... ½ to 2 „
Cake and Whisking Machine	⅛ to 2 „
Coffee Roasting Machine	.. 1 to 2 „
Combined Blending and Sifting Machine	1 to 3 „
Crane—Worked by friction wheels, 10 cwt., 60 ft. per minute	... 3 to 4 „
Worked by friction wheels, 10 cwt., 90 ft. per minute	4 to 5 „
Cutting Machine	... ¼ to 2 „
Dough Brakes	2 to 6 „
Dough Kneading Machines—½ sack	... 1 to 1½ „
1 sack	1½ to 2 „
1½ sack	3 „
2 sack	4 „
3 sack	... 5 to 6 „
4 sack	6 to 7 „
Goods Hoist—Worked by gearing, 10 cwt., 60 ft. per minute	... 4¼ to 5 „
Jewellers' Plant	from 3 „
Organ Blowing	... 1 to 2 „
Pressure Blowers for foundry work	1 to 76 „
Press Pump	... 3 to 4½ „
Sack Cleaner	1 to 1½ „
Saddlers' Sewing Machines	... ½ to 1 „

TABLE X. *(continued).*

MISCELLANEOUS TRADES *(continued).*

Sewing Machines	$\frac{1}{4}$ to $\frac{1}{2}$ H.P.
Shafting $2\frac{1}{4}$ in. diameter, per 100 ft. at 120 revolutions	1 „
Sifting and Dressing Machine	$\frac{1}{4}$ to $\frac{1}{2}$ „
Stuff-folding Machines and Cuttling Machines	$\frac{1}{2}$ to 1 „
Sugar Mills—Hand or steam	$\frac{1}{8}$ to $\frac{3}{4}$ „
Watch-Makers' Plant	1 „
Woodburn Disintegrator...	$3\frac{1}{2}$ to 6 „

The cost of running or working cost of some of the machines given in Table X. will vary very considerably according to the circumstances under which they have to be driven. The figures which are there stated as the approximate horse-power required represent the power as applied directly to the machine itself, without the intermediate gearing of shafting and belts which is so necessary an adjunct with other forms of motive power. In some cases shafting and belting are unfortunately necessary even with electric motors, but the loss of efficiency due to this cause can be very largely minimised. We will now deal with a few particular cases in which the application of electric motors has already been proved of great advantage.

Electric Traction for Tramways.—This must be considered to be one of the first and most popular applications of electricity as supplied from a central generating station. It is becoming more and more extensively adopted, and electrical tramcars are now in operation in about twenty districts in the United Kingdom.*

A great deal of importance has been attached to electric traction as a valuable factor in the day-load output for the electric light machinery. No doubt it is, and will be for some little time to come, a valuable help in increasing the works load-factor. But the demand for the electric light is extending very rapidly, and must ultimately assume

* "Mechanical Features of Electric Traction." Paper on, by Philip Dawson, in *Proceedings* of Institution of Mechanical Engineers, 10th February, 1898.

such proportions that the maximum power required for electric traction will soon sink into insignificance in comparison. It will therefore be well for all electric light committees to be wise in time, and foster and encourage the use of electric motors for industrial purposes, in *addition* to that which may be required for electric traction. It is a matter of comparatively simple calculation to total up the entire horse-power necessary to run a three-minute service of cars on every possible route in a township. For instance, take a town with ten routes, each three miles in length, and the cars running at ten miles an hour on gradients of, say, 1 in 30. Each car will require an average of 30 horse-power, and there will be sixty cars running, or an equivalent of 1,800 horse-power. In such a town, the demand in ten years' time for the electric light, would probably reach quite 20,000 horse-power. At the present time, however, a line of electric tramcars would prove of immense benefit to many of the smaller electric light stations, in reducing the standing charges, and helping a small concern to be managed profitably. The subject is one to which a great deal of attention has already been given. There are many excellent treatises* on the subject, from which every information may be gathered. To these the reader is referred, and also to the many Papers which have been read by engineers and electricians before the scientific societies.

Letterpress and Lithographic Printing Machinery.—This class of machinery has been successfully operated for upwards of two years, by electric motors applied direct to the main driving shaft of the machines, or by toothed gearing. Since the first attempts were made, many improvements have been introduced, until, at the present time, nearly all the leading houses in the trade have either adopted the system of

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* "Electric Railways and Tramways: their Construction and Operation," by Philip Dawson. Published by *Engineering*, Bedford Street, Strand, London, W.C.

"Electric Tramways Popularly Explained," by H. Scholey. Published by H. Alabaster Gatehouse & Co., 4 Ludgate Hill, London, E.C.

"Direct-Coupled *v.* Belt-Driven Units for Electric Traction," by A. H. Gibbings (*Railway World*, for April and May, 1897).

"Electric Traction." Papers on, by J. Rider, J. Hesketh, and R. C. Quin, in *Proceedings* of Municipal Electrical Association for 1896 and 1898.

"Electrical Traction," by Ernest Wilson. Published by Edward Arnold, 37 Bedford Street, Strand, London, W.C.

"Tramways: Their Construction and Working," by D. K. Clark. Published by the Electrician Printing and Publishing Co., London, E.C.

single machine driving in its entirety, or some such modifications of it, as best seem to suit their particular methods of working. Wherever the system of shafting and belts is used to transmit the energy generated by the driving engine, there is a great loss of power. If, for instance, we suppose a room with ten printing machines in it, and only one at work, the full power used in driving the engine, shafting, and belting, for the remaining nine machines, is simply going to waste. Of course, in such an instance, a clutch or other contrivance may be introduced to isolate a particular line of shafting, but still the fact remains, that a large mass of machinery, absorbing an excessive amount of steam or gas engine power, has to be kept wastefully running whilst one machine only is being utilised. Where the clutch arrangement is not in use, there is the spectacle of the belting and loose pulleys of nine machines set running, as an inevitable consequence of working one. This is but a typical illustration of what may be seen daily in a good many printing offices. To the smaller printer the usefulness of the electric motor can scarcely be over-estimated. If he is on the line of supply of electricity he may dispense with his gas engine, and so save space, and probably make room for another printing machine ; while he economises in that he only pays for the power consumed during the time the machines are actually at work. As to the larger firms, the saving in their case is even greater in proportion. It is doubtful if they realize the immense loss that occurs by the use of the old methods of driving their machinery. In one case, where tests were made, it was found that *the shafting and belts absorbed 56 per cent. of the actual power generated* by the engine.

It may be also pointed out that electric driving is the only system in which the exact power required to drive a machine can be accurately ascertained. An ampère-meter in the circuit shows at once if more power is being given off by the motor than is requisite, and thus the attendant can see at once that there is a drag somewhere. In one case, where a motor had been put in with a belt system, it was found, after it had been a short time at work, that the power indicated was

slowly increasing until it had reached 40 per cent. over and above what was required when the motor was first started. An expert was called in, and it was discovered that the loss of power was caused by slack

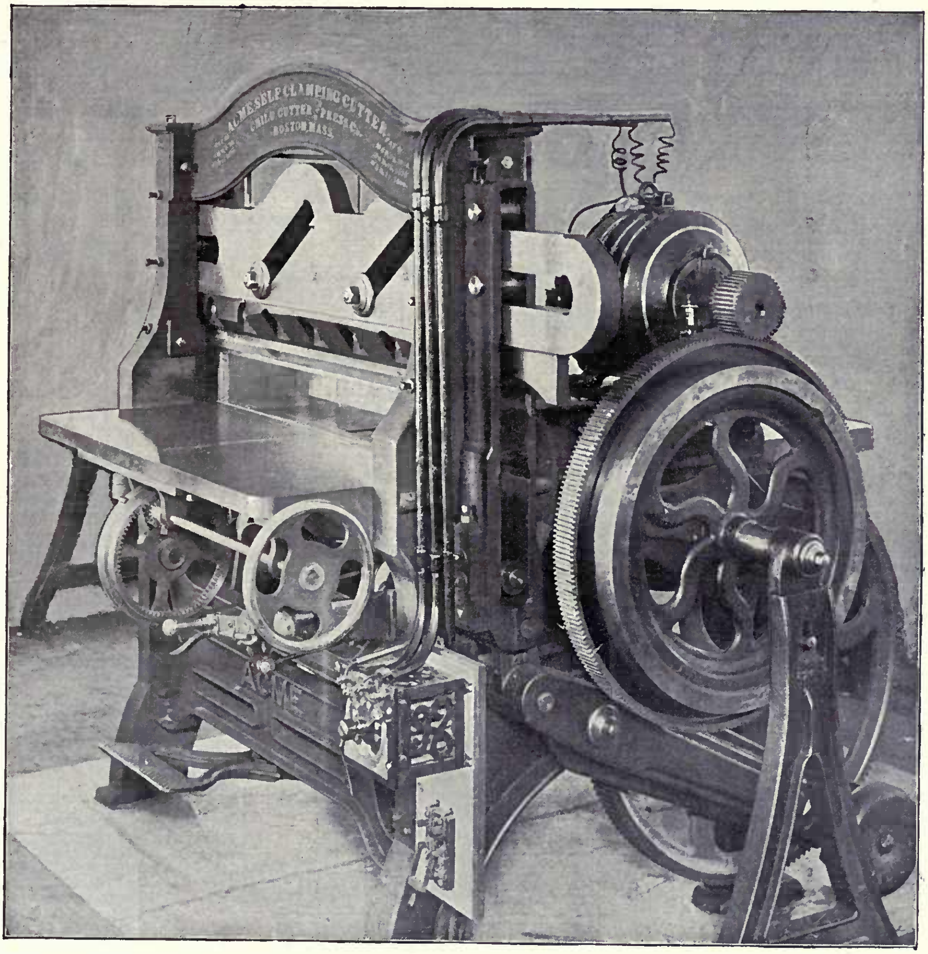


Fig. 6.

belts, and when they were tightened up the indicator went back to the normal point. This is a case in which, had a steam or gas engine been used, the loss of power might have passed unnoticed.

Beyond the points which have just been mentioned, by which considerable economy may be effected with electric motors, it is exceedingly difficult to ascertain any reliable figures as to the actual cost of running. This is due to the widely different and greatly varying capacities of these machines. One instance must suffice for which the author can vouch. The machine is made by the Northern Press Engineering Co., Limited, South Shields (Armand's patent), with a capacity of 28,000 copies per hour, including counting, folding, &c., and is used in the printing of one of the evening papers in Bradford. The current is supplied from the Bradford Corporation mains at 2d. per Board of Trade unit to a 22 horse-power motor, which is coupled direct to the machine.

In Fig. 6 an illustration is shown of an electric motor fixed to a guillotine, from which it will be seen that the motor is out of the way of the operator, the motion being conveyed by means of gearing on the outer rim of the flywheel. The small knob (being the handle of the starting switch), seen at the right-hand side of the machine, under the hand wheel, places the motor entirely under the control of the operator.

Table XI. gives the number of motors and the power used by several well-known printing establishments in this country.

Cranes and Hoists.—In every town with any pretension to size, warehouse and other cranes and passenger and goods hoists are in general use. Where these labour and time-saving lifting gears are few in number, due to the expensiveness or inapplicability of the motive power available, the electric motor is especially a boon. In many cases owing to the infrequency in the use of some cranes, hand power is still the method very largely relied upon, and this must be, in these days of business despatch, most expensive and unsatisfactory. The advantages and economy of the electric motor for driving cranes and hoists are very similar to those arising out of their use with printing machinery, viz. :—

1. The possibility of placing the motor close up to its work.
2. Direct coupling or one reduction gearing of high efficiency.

3. The economy resulting from the power used being practically proportionate to the work done.

In fact, these motors have so much to recommend them, that municipalities would be well advised in initiating a system of letting out

TABLE XI.—*List of Firms using Electrically-driven Printing Machines.*

Name of Firm	No. of Motors in use	Total Electrical horse-power
A. G. Jeans, *Liverpool Daily Post* and *Liverpool Echo* Newspapers, Liverpool	3	82
A. and W. Kennedy, Glasgow	1	3
Alabaster, Passmore and Co.	25	56
Alex. Baird and Son, Glasgow	5	16
Bazaar, Exchange and Mart	5	62
Bemrose and Sons, Derby	5	22
C. Tinling & Co., *Daily and Weekly Courier* and *Evening Express* Newspapers, Liverpool	4	56
Chorley and Pickersgill, Leeds	2	8
Clowes' Printing Works	10	43
Co-operative Wholesale Society, Limited (Printing Department), Longsight, Manchester... ...	47	102
Daily Argus, Bradford	3	46
Daily Telegraph, Bradford	2	9
Evening Telegraph, Belfast	3	65
Eyre and Spottiswoode	1	2
Graphic and *Daily Graphic*	6	21

TABLE XI.—*(continued)*.

Name of Firm	No of Motors in use	Total Electrical horse-power
Hazel, Watson and Viney, Limited... ... ... (Per Messrs. Marryat and Place)	2	12
Hills and Co.	1	1
Hudson, Scott and Co., Carlisle	9	37
John Brown, Edinburgh	17	28
John Dale and Co., Bradford	13	25½
Johns, Son and Watts, Limited...	3	12
Kelly's Directories, Limited, London	1	6
Kenrick and Jefferson, Birmingham	8	28
Linotype Co., Limited, Manchester	7	66
M. P. McCoy	3	9
Mardon, Son and Hall, Bristol	18	82
Sir J. Causton and Sons	24	70
Swan Electric Engraving Co., London	1	2
Temple Press, Limited	2	5
The Echo Newspaper Office... ... ... (Per Machinery Trust, Limited)	2	8
The Morning Post Newspaper, London ... ... (Per Messrs. Berry, Harrison and Co.)	1	35
Thomas Forman and Sons, Nottingham	3	7
W. and G. Baird, Limited, *Belfast Evening Telegraph* Newspaper	3	65
W. H. Brocklehurst, Bradford	1	2
W. M. Crockett, The "Ulster" Newspapers, Belfast	1	4
Waterlow and Sons, Limited	21	316

motors on hire, thereby removing one of the difficulties in the way of rapid adoption of this very adaptable and excellent form of power. This aspect of the case will, however, be dealt with in a succeeding section. Beyond the many advantages of the electric motor as a power agent only, its peculiar adaptability to all sorts and conditions of operation with the most economical results over and above that of any other form of power may be seen from the following example. We will suppose that a warehouse block of buildings, containing from five to six storeys, is let out to several tenants, and that some of these require the use of a crane which is common to each of the five or six floors. Such cranes are usually fixed, including the motive power and gearing, at the top of the building, and this is usually found the most convenient place if the power generator is either a gas engine, oil engine, or electric motor. If steam or hydraulic power is used, the engine or apparatus, as the case may be, is usually placed in the basement, and the crane is geared either by a vertical shaft from the bottom to the top of the building, or by counter-shafting on each floor, coupled by belt gearing. With the gas engine, the oil engine, and the steam engine there arises the necessity to keep these machines continually running whenever the cranes are required or likely to be required. With hydraulic power and electricity, this drawback is overcome, as each may be started automatically, when required, by means of valves and switches respectively at any reasonable distance from the machines themselves. Now, in the example which is here assumed, it is clear that the principal and essential features in connection with the use of these cranes are—

1. That the power is required intermittently only.

2. That it is necessary that the crane may be operated and entirely controlled from any and either of the floors or storeys.

3. That the expenditure of power should, if possible, be restricted to the time when the crane is required in actual operation.

These conditions are met in the most complete and perfect manner by an electric motor. An electric motor occupies a smaller

space, power for power, than any of the other types. It can be fixed on beams or girders just under the roof of the building, and directly geared to the crane mechanism. It can be operated, *i.e.*, started and stopped, in a few seconds, regulated in speed, and controlled from any floor, by means of a rope or lever. All other forms of power fail to comply with one or other of these conditions, as has already been mentioned in the case of gas, oil, or steam. Where hydraulic power

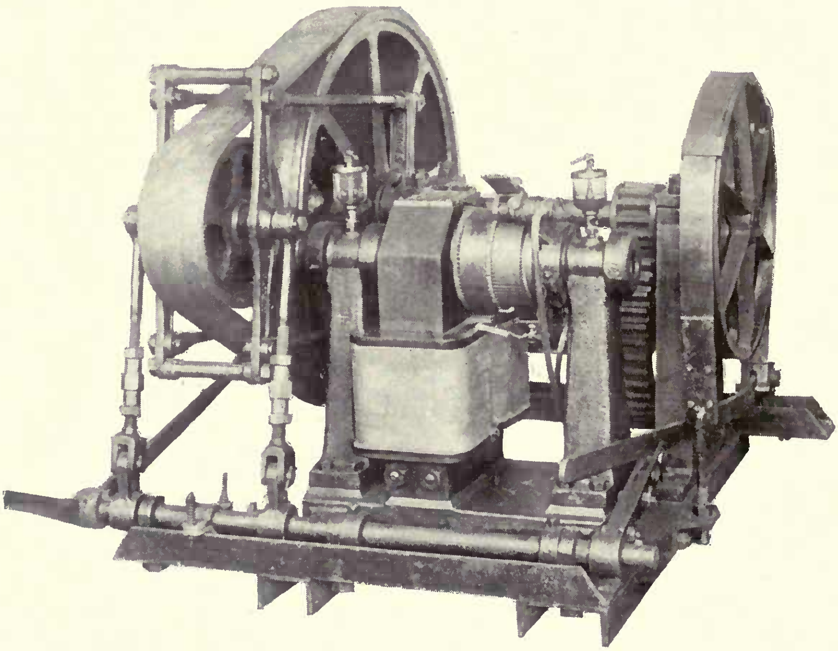


Fig. 7.

is used the efficiency in working is very low. The electric motor automatically adjusts itself, and uses no more power than is required to lift the load, whether great or small. This is not so, however, with an hydraulic lift, which, unless specially constructed at great cost with a series of cylinders and other complications, takes almost as much power to lift the empty cage or chain as to lift the full load. In the Union Warehouses, at Bradford, which are used for large storages of

wool bales, and which contain five floors, there are in use twenty-two electric motors of 5 horse-power each, and operating twenty-two cranes. These cranes were originally worked by hydraulic power, and in one year the cost of working and repairs due to breakages of pipes through frost amounted to £700. When electric motors were substituted, and supplied with electricity from the Corporation electric light mains at $2\frac{1}{2}$d. per Board of Trade unit, the cost dropped to £250 per annum.

An illustration of the method of gearing an electric motor to a goods lift and warehouse crane winch is shown in Fig. 7.

In Table XII. the cost of working an electric warehouse crane is given. The test load was a bale of wool weighing 5 cwt. The cranes used for this purpose are subjected to very rough handling. The bales being of a soft nature take no harm in being knocked about, and hence the cranes and motors are frequently taxed to their utmost capacity.

The test given in Table XIII. was taken with an Otis Electric Elevator in the Offices of the Sun Insurance Company, Glasgow.

It is not proposed here to consider fully the important question of gearing, as to what are the most efficient and the most adaptable forms for the various purposes for which the cranes are employed, such as overhead travellers, jib cranes, winches, hoists, &c. The reader has already been referred to special treatises on the subject. It sometimes occurs, however, that the gearing is wretchedly bad, and then the efficiency of the electric motor as supplied from the Corporation electric light mains is liable to be called into question. A few remarks, therefore, on the general efficiency of cranes and gearing may not be out of place.

Efficiency of Gearing.—The efficiency of the crane is really the most important point, and should be considered most carefully. A crane of any description cannot be worked economically if inefficient. In considering the efficiency of an electric crane, it is only misleading to take the efficiency of the motor or any part of the gearing separately. To say that the efficiency of the motor is 92 per cent., and the loss

TABLE XII.—*Test of Warehouse Crane.*

Weight of wool bale lifted = 5 cwt.

Time in seconds		Board of Trade unit	Total distance raised and lowered	Actual cost at $2\frac{1}{2}$d. per unit
Up	18·0	·0181	31 feet	·04525
Down	5·3	·0019	,,	·00475
Up	18·0	·0181	,,	·04525
Down	5·3	·0019	,,	·00475
Up	18·0	·0181	,,	·04525
Down	5·3	·0019	,,	·00475
Up	18·0	·0181	,,	·04525
Down	5·3	·0019	,,	·00475
Up	18·0	·0181	,,	·04525
Down	5·3	·0019	,,	·00475
Up	18·0	·0181	,,	·04525
Down	5·3	·0019	,,	·00475
Up	18·0	·0181	,,	·04525
Down	5·3	·0019	,,	·00475
Up	18·0	·0181	,,	·04525
Down	5·3	·0019	,,	·00475
Up	18·0	·0181	,,	·04525
Down	5·3	·0019	,,	·00475
Up	18·0	·0181	,,	·04525
Down	5·3	·0019	,,	·00475
233		·2000	620 feet	·50000

Cost of raising and lowering therefore = $\frac{1}{2}$d.

The motor was left running whilst lowering the bale, which would be the probable conditions of ordinary operation.

TABLE XIII.—*Sun Insurance Company, Glasgow.*

Rise of Car, 74 feet 9 inches.

Speed, 170 feet. Volts, 220. Car designed to carry 1,000 pounds.

Load	Weight	Time in seconds	Ampères	Cost at 1d. per B.T.U.	Total	Cost at $2\frac{1}{2}$d. per B.T.U.
1 Man ...	149 lbs.	Up 24 secs.	1·5	·0022		
		Down 26 „	26·	·0446	·04682	·1170
2 Men ...	289 „	Up 25 „	4·	·0061		
		Down 28 „	19·	·0324	·0385	·0962
3 „ ...	457 „	Up 26 „	7·	·0118		
		Down 28 „	15·	·0258	·0376	·0940
4 „ ...	597 „	Up 26 „	10·	·0157		
		Down 28 „	10·	·0169	·0326	·0815
5 „ ...	757 „	Up 26 „	15·	·0231		
		Down 27 „	7·	·0115	·0346	·0865
6 „ ...	911 „	Up 26 „	19·	·0302		
		Down 27 „	5·	·0082	·0384	·0960
7 „ ...	1051 „	Up 27 „	25·	·0413		
		Down 26 „	2·	·0031	·0444	·1110
8 „ ...	1225 „	Up 29 „	29·	·05		
		Down 26 „	1·	·0015	·0515	1287

in gearing is very slight, does not give us the efficiency of the crane, as we know that in worm gearing, for instance, there is at least a loss of 25 to 30 per cent. ; thus, a good motor and a bad gear make a bad crane, and *vice versâ*. It being a very simple matter to test the efficiency of an electric crane, the author would recommend an engineer to see it tested himself. It is a matter respecting which there can be no doubt or dispute, it being well known that 746 watts are equivalent to one horse-power, and that it requires one horse-power to raise 33,000 lb. one foot per minute. This being so, it is a simple matter to get a weighed load, a tape marked in feet, and a stop-watch. A recording meter being inserted in the electric mains, the speed of lifting the load may then be obtained, and we get two sets of results, viz., the electrical horse-power put into the crane and the horse-power actually utilised in raising the load. In this manner we get the real efficiency of the crane, and can then calculate the cost of working per ton under given conditions.

If the efficiency of the electric motor is known in the first instance, the actual efficiency of the crane gearing can then be accurately ascertained. A good combination, in which every necessary motion can be obtained, ought to give from 72 to 80 per cent. efficiency. If, however, only one simple motion is required, then, with a single reduction gear or by direct coupling, the efficiency obtainable will be from 80 to 90 per cent.

General Advantages.—We have now dealt with the application of the electric motor to three important and useful purposes, viz., Letter-press and Lithographic Printing, Electric Traction, and Cranes and Hoists. In connection with these, an endeavour has been made to show the special features of electric driving as applied thereto. It will be evident, however, from the great similarity which exists between the requirements of nearly all mechanical operations, that these distinctive and special features would render the electric motor equally effective in regard to other classes of machinery. Indeed, only very slight modifications of gearing and regulating apparatus, are necessary

to make it adaptable to any set of circumstances and conditions. Without, therefore, specially considering the other applications given in Table X., viz., Ærated Water, &c., Plant, Automatic Electric Signs, Bookbinding and Box-making Plant, Brush-making Machinery, Carpet-beating Plant, Cycle-making and Repairing, Dental Surgery Appliances Founders, Laundry Machinery, Metal-working Machinery, Paper-making Plant, Packing-case Making Machinery, Umbrella and Stick-making Plant, Ventilating Fans, Wood-working Machinery, and Miscellaneous Trades, it will suffice if we now enumerate, in the form of a summary, the general advantages of the electric motor. They are as follows :—

1. Speed practically constant under varying loads, if required.

2. The cost in repairs is practically *nil*, with a well-designed machine.

3. The smaller sizes may be fixed to a wall if necessary.

4. Occupies very small space, viz., about four feet square, for any size up to 10 brake-horse-power.

5. Perfect silence in working, absence of smell, and does not give off any gases.

6. Requires no attention, except oiling the bearings once or twice a week, and renewing the brushes occasionally.

7. Absolute freedom from vibration, thereby enabling the motor to be placed in any position in a building without expensive foundations.

8. The larger sizes can be readily adjusted to take up any slack in the belt, instead of cutting the belt and making a new joint.

9. A motor can be started and stopped by the simple operation of a switch. This arrangement obviates running the motor when not required, and of course effects considerable economy in the use of power.

10. As there is no reciprocating motion, the running is the steadiest that can possibly be obtained. The motors are therefore suitable for any kind of work.

11. Where a number of machines are used, and extensions are likely to be made, the use of additional motors is much cheaper and more adaptable to circumstances than extensions of shafting and counter-

shafting. Odd and additional plant may be put down anywhere, doing away with the necessity of setting out with a line of shafting, and thus floor space can be utilised to greater advantage. The space above would also be free from open belts, cross belts, pulleys, counter-shafting, and other gearing. When these separately-driven machines were not in use, there would be no long lengths of shafting being uselessly driven, and wasting power.

12. Motors can be coupled direct to any class of machinery. They can be placed at any point where they will be least in the way, and in some cases an advantage may be derived from running two or more small machines from the one motor. For instance, book-binders' stitching machines, of which a number are usually worked on one floor, might with advantage be coupled this way, as but small power is required, and not all being in operation at the same time, a single motor would be sufficient for the whole. Electric driving is the only system by which the *exact* power required to drive a machine can be accurately ascertained. Every other form of power, including steam engines, gas engines, oil engines, and hydraulic engines, necessitates the use of a brake method in order to ascertain approximately the power required or developed. With electric power, and by means of an ammeter or watt-meter in the main circuit, the maximum and all variations of power is shown at a glance at any time while the motor is actually working under its ordinary conditions.

Cost of Working.—Having dealt with the general advantages of electric motive power, we will now consider briefly the actual cost of working, instituting a comparison with the cost of gas, oil, and steam. Hydraulic power may be omitted from the comparison, as the purposes to which it may be applied are very limited, the means of handling and regulating it are costly, and the repair and maintenance are serious items. In addition to these drawbacks the service is liable to be affected by drought in summer, and by frost in winter. It may therefore be dismissed as being by no means a competitor with electricity.

In order to make a fair comparison of the costs of power by

steam, gas, oil, and electricity respectively, it must first of all be determined what we are to assume as the respective prices charged for these commodities. But there are other items which must also be taken into consideration, and these may be stated as follows :—

1. Horse-power of plant.
2. Number of hours per annum during which the power is required.
3. Efficiency of plant.
4. The capital outlay of the complete plant.
5. The interest and depreciation on outlay.
6. Cost of repairs.
7. Rent, rates, and taxes.
8. Wages for attendance.
9. Efficiency of gearing.

We will take these items *seriatim*, and assume the relative prices to be 12s. 6d. per ton for coal, 3s. per 1,000 cubic feet for gas, 4d. per gallon for petroleum oil, and 2d. per unit for electricity. In order to reduce these to a common basis for comparison, it is necessary to obtain the cost per brake-horse-power per hour. In the best engines of each type respectively, it has been found that 4 lbs. of coal for steam engines, 25 cubic feet of gas for gas engines, 1½ pints of oil for oil engines, and 830 watts for electric motors, are each equivalent to 1 brake-horse-power per hour. Hence in actual cost in pence per hour we get :—

Steam @ 12s. 6d. per ton	·26d.
Gas @ 3s. per 1,000 cubic feet	·80d.
Oil @ 4d. per gallon	·75d.
Electricity @ 2d. per 1,000-watt hours	1·66d.

These figures represent the brake-horse-power on the pulleys of the engines and motors, and also (what is of equal and immense importance in making this comparison) they represent the result at the *full load* of the engine. With a *varying load* the efficiency of the engines rapidly decreases, while that of the electric motor remains practically the same, as will be shown further on. The next two items

to be considered are :—

1. The horse-power of the plant ; and

2. The average number of hours per annum during which the plant is required.

It may be admitted that a steam plant is never put down for less than about thirty horse-power, and hence that may be taken as a basis. The number of horse-power hours per day may be taken as eight, six, and four respectively, although the first is very rarely reached. A steam engine may, for instance, be running for nine-and-a-half hours, but the load will be constantly varying from a quarter to possibly a three-quarter load, sometimes reaching full load, for short periods. Hence the average must be taken, and, allowing 300 working days per year, we get 2,400 hours, 1,800 hours, and 1,200 hours, for eight, six, and four hours per day respectively ; or for thirty horse-power, 72,000, 54,000, and 36,000 horse-power hours per annum respectively. This brings us to the third point, viz., the efficiency of the plant at the average loads, which is found to be as shown in Table XIV.

TABLE XIV.

Plant	Cost of Fuel per Brake-Horse-Power per hour on varying Loads		
	Horse-Power Hours per Annum		
	72,000	54,000	36,000
Steam	·26d.	·34d.	·46d.
Gas	·80d.	1·00d.	1·20d.
Oil	·75d.	·94d.	1·12d.
Electric	1·66d.	1·66d.	1·66d.

The next items for consideration have a much more important bearing on the actual and comparative costs of running. They consist of:—

1. Capital outlay.
2. Interest and depreciation.
3. Repairs and maintenance.
4. Rent, rates, and taxes.
5. Attendance.

For a 30 H.P. plant these may be estimated as in Table XV.

TABLE XV.—*Cost per Annum.*

Items	Steam £	Gas £	Oil £	Electricity £
Capital	£500	£250	£250	£300
Interest and Depreciation, 10 per cent.	£50	£25	£25	£30
Repairs, 5 per cent.	£25	£12 10s.	£12 10s.	(2½ %) £7 10s.
Rent, &c., for space occupied	£10	£5	£5	*Nil.*
Attendance	£100	£50	£50	*Nil.*
Total	**£185**	**£92 10s.**	**£92 10s.**	**£37 10s.**
Cost per B.H.P. per hour, for 72,000 hours = ...	·61d.	·30d.	·30d.	·13d.
Cost per B.H.P. per hour, for 54,000 hours = ...	·82d.	·41d.	·41d	·17d.
Cost per B.H.P. per hour, for 36,000 hours = ...	1·22d.	·61d.	·61d.	·26d.

This table (XV.), together with Table XIV., provides us with the necessary data, wherewith to ascertain the actual cost of a brake-horse-power hour for the respective plants, under similar conditions, but with varying loads. These combined results are given in Table XVI.

TABLE XVI.—*Average cost per Brake-Horse-Power Hour, in Pence, for Varying Annual Loads.*

Plant		72,000 Hours Per hour	54,000 Hours Per hour	36,000 Hours Per hour
Steam	Running Costs	·26d.	·34d.	·46d.
	Capital Costs	·61d.	·82d.	1·22d.
	Total	**·87d.**	**1·16d.**	**1·68d.**
Gas	Running Costs	·80d.	1·00d.	1·20d.
	Capital Costs	·30d.	·41d.	·61d.
	Total	**1·10d.**	**1·41d.**	**1·81d.**
Oil	Running Costs	·75d.	·94d.	1·12d.
	Capital Costs	·30d.	·41d.	·61d.
	Total	**1·05d.**	**1·35d.**	**1·73d.**
Electricity ...	Running Costs	1·66d.	1·66d.	1·66d.
	Capital Costs	·13d.	·17d.	·26d.
	Total	**1·79d.**	**1·83d.**	**1·92d.**

It will be seen that these figures as they stand in the table are not favourable to electricity as a motive power. This is due to two reasons : first, the comparison between the respective motors is that of brake-horse-power taken at the shaft of each machine ; and secondly, the price for electricity for power purposes, viz., 2d. per unit, is high.

To take the first of the above causes, it must be admitted that in comparing the costs of running at the point where the power is delivered by each engine, viz., at the pulley of the crank or armature shaft, the electric motor is not much cheaper and in this instance is dearer than the other three. It is clear, however, that in actual practice, that point is not where the comparison is either useful or needed. The point at which the comparison should be made is the point of application of the power to the machinery or object to be operated or driven. Unless the gas, oil, or steam engine is to drive one machine only, the necessity arises in the case of these engines to use intermediate gearing in the forms of shafting, belting, ropes, spur wheels, bevel wheels, &c. This gearing forms a very much greater proportion of the power required "*per machine*" than would appear to be the case. It may be taken as varying from 25 per cent. to 100 per cent. above the actual power of the machines when all are in operation. It is no uncommon occurrence, however, for only a small proportion of the machines to be at work while the engine is driving the whole of the shafting. Electric motors of course do away with nearly all this complication and waste because they can be coupled direct to each separate machine, and in addition are not required to run when the machine is not in use. We can go even further than this, and start and stop the motor in a moment, as the work on the machine is varied. As regards steam, gas, and oil, therefore, it will be necessary to at least double the figures given in Table XVI., before accepting them as representing the actual working cost.

There is also another important feature in connection with the economy of electric motors, viz., the efficiency at varying loads. It may be taken for granted that no single piece of machinery maintains

a full load for any considerable length of time, and hence the efficiency of the driving-engine at quarter, half, and three-quarter load, &c., becomes important. The efficiency of the electric motor is much higher at all loads than either steam, gas, or oil engines. The cost, therefore,

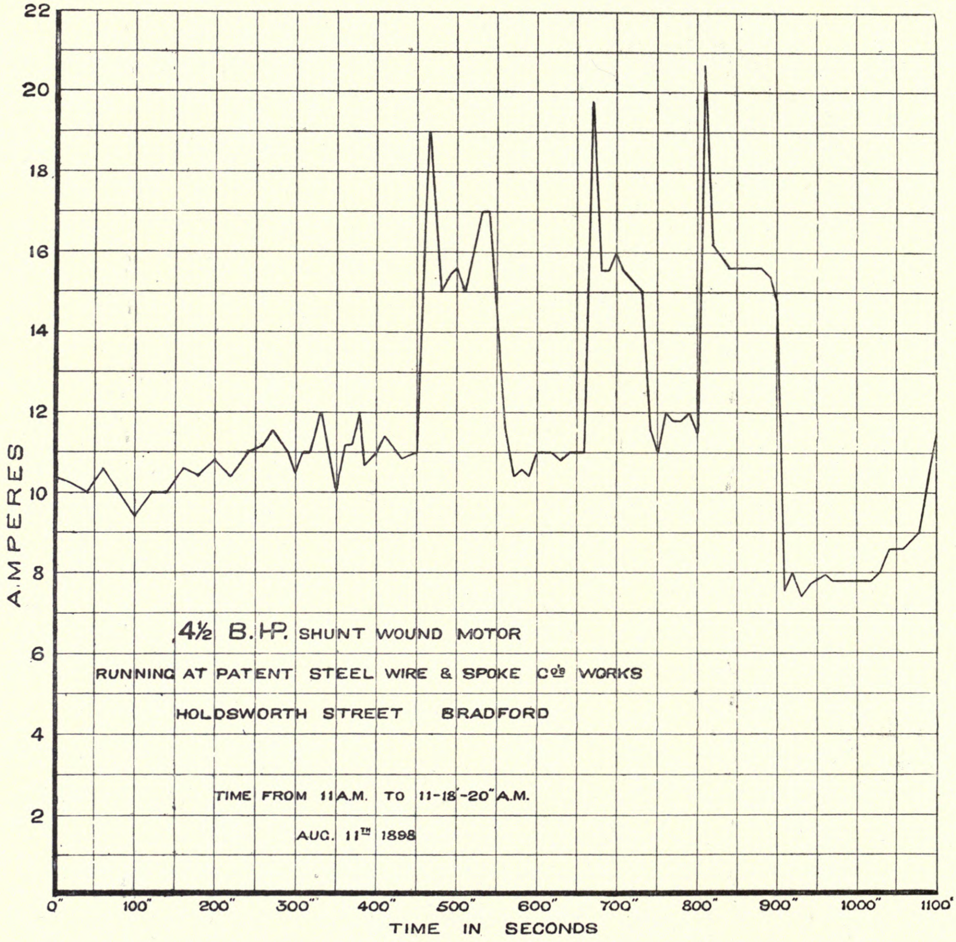


Fig. 8.

of running an electric motor will be represented by the actual resultant taken on the average of the varying loads. This feature is illustrated in the accompanying curve (Fig. 8), which has been taken from modern

wire-working machines. It will be seen that the maximum horse-power was 6·4, and the duration of time 18 minutes, which, if the maximum power had been a constant load, would represent 2 horse-power hours. But after the resultant has been carefully obtained with a planimeter, the actual horse-power hours are found to be 1·06. This difference between the maximum horse-power required and the mean horse-power used is rarely taken into account or even understood by many small power users. It is a most difficult thing to get them to appreciate it.

TABLE XVII.

Electrical Horse-Power		Cost per Hour in Pence at varying prices per Board of Trade Unit				
		1d.	1½d.	2d.	2½d.	3d.
80 per cent. Efficiency	½	·46d.	·69d.	·92d.	1·15d.	1·38d.
	1	·93d.	1·39d.	1·86d.	2·32d.	2·79d.
	2	1·86d.	2·79d.	3·72d.	4·65d.	5·58d.
	3	2·79d.	4·18d.	5·58d.	6·97d.	8·37d.
	4½	4·18d.	6·27d.	8·36d.	10·45d.	12·54d.
	6	5·58d.	8·37d.	11·16d.	13·95d.	16·74d.
	10	9·32d.	13·98d.	18·64d.	23·30d.	27·96d.

The second reason of the unfavourable comparison of cost per brake-horse-power hour for electric power as given in Table XVI., and to which brief reference has already been made, is that the price of 2d. per unit is high. It will be shown that electricity for power purposes can be supplied at 1d. per unit from a central electric lighting station, and that a considerable profit can be made at that price. There are very few instances in which any private steam or gas plant can compete with electricity at 1d. per unit. In some towns, however, the charge for electricity for motive power is as high as 3d. per unit. The figures in Table XVII. give the cost per brake or

TABLE XVIII.

The charge for Electricity for Power purposes is **2½d. per Unit,** for an average use for four hours and under per day of the maximum power actually required. If the power is used for an average of over four hours per day, the charge will be reduced in accordance with the following scale.

SLIDING SCALE OF CHARGES FOR ELECTRIC POWER, CALCULATED UPON SIX MONTHS USE.

Maximum demand of current		Equivalent of current in horse-power required	Average daily use of 4 hours	Average daily use of 5 hours	Average daily use of 6 hours	Average daily use of 7 hours	Average daily use of 8 hours
AMPÈRES			**Units at** 2*d.*	**Units at** 1¾*d.*	**Units at** 1½*d.*	**Units at** 1¼*d.*	**Units at** 1*d.*
Over	Under	H.P.	Exceeding	Exceeding	Exceeding	Exceeding	Exceeding
—	5	1·54	550	650	775	950	1,200
5	7½	2·31	825	975	1,162	1,425	1,800
7½	10	3·08	1,100	1,300	1,550	1,900	2,400
10	12½	3·85	1,375	1,625	1,937	2,375	3,000
12½	15	4·62	1,650	1,950	2,325	2,850	3,600
15	17½	5·39	1,925	2,275	2,712	3,325	4,200
17½	20	6·16	2,200	2,600	3,100	3,800	4,800
20	22½	6·93	2,475	2,925	3,487	4,275	5,400
22½	25	7·70	2,750	3,250	3,875	4,750	6,000
25	27½	8·47	3,025	3,575	4,262	5,225	6,600
27½	30	9·24	3,300	3,900	4,650	5,700	7,200
30	32½	10·02	3,575	4,225	5,037	6,175	7,800
32½	35	10·79	3,850	4,550	5,425	6,650	8,400
35	37½	11·56	4,125	4,875	5,812	7,125	9,000
37½	40	12·33	4,400	5,200	6,200	7,600	9,600
40	42½	13·10	4,675	5,525	6,587	8,075	10,200
42½	45	13·87	4,950	5,850	6,975	8,550	10,800
45	47½	14·64	5,225	6,175	7,362	9,025	11,400
47½	50	15·41	5,500	6,500	7,750	9,500	12,000
50	52½	16·18	5,775	6,825	8,137	9,975	12,600
52½	55	16·95	6,050	7,150	8,525	10,450	13,200

TABLE XVIII. *(continued).*

Maximum demand of current		Equivalent of current in horse-power required	Average daily use of 4 hours	Average daily use of 5 hours	Average daily use of 6 hours	Average daily use of 7 hours	Average daily use of 8 hours
AMPÈRES			Units at 2*d.*	Units at $1\frac{3}{4}$*d.*	Units at $1\frac{1}{2}$*d.*	Units at $1\frac{1}{4}$*d.*	Units at 1*d.*
Over	Under	H.P.	Exceeding	Exceeding	Exceeding	Exceening	Exceeding
55	57½	17·72	6,325	7,475	8,912	10,925	13,800
57½	60	18·49	6,600	7,800	9,300	11,400	14,400
60	62½	19·26	6,875	8,125	9,687	11,875	15,000
62½	65	20·04	7,155	8,450	10,075	12,350	15,600
65	67½	20·81	7,420	8,775	10,462	12,825	16,200
67½	70	21·58	7,700	9,100	10,850	13,300	16,800
70	72½	22·35	7,975	9,425	11,237	13,775	17,400
72½	75	23·12	8,250	9,750	11,625	14,250	18,000
75	77½	23·89	8,525	10,075	12,012	14,725	18,600
77½	80	24·66	8,800	10,400	12,400	15,200	19,200
80	82½	25·43	9,075	10,725	12,787	15,675	19,800
82½	85	26·20	9,350	11,050	13,175	16,150	20,400
85	87½	26·97	9,625	11,375	13,562	16,625	21,000
87½	90	27·74	9,900	11,700	13,950	17,100	21,600
90	92½	28·51	10,175	12,025	14,337	17,575	22,200
92½	95	29·28	10,450	12,350	14,725	18,050	22,800
95	97½	30·06	10,725	12,675	15,112	18,525	23,400
97½	100	30·83	11,000	13,000	15,500	19,000	24,000

If a consumer's maximum demand exceeds 100 amperes, by any of the demands in the several lines of the above table, then the number of units may be ascertained by adding the particular line of increase to the bottom line of the table, thus:—Say the maximum demand be 125 ampères (38·53 horse-power), then by adding the line "over 22½ and under 25 ampères" (7·70 horse-power), to the line "over 97½ and under 100" (30·83 horse power), we obtain:—

Over	Under							
97½	100	=	30·83 ...	11,000 ...	13,000 ...	15,500 ...	19,000 ...	24,000
22½	25	=	7·70 ...	2,750 ...	3,250 ...	3,875 ...	4,750 ...	6,000
120	125	=	38·53 ...	13,753 ...	16,250 ...	19,375 ...	23,750 ...	30,000

and so on.

electrical horse-power per hour for varying prices per Board of Trade unit. This table should be referred to only in conjunction with Fig. 8, and the explanation thereto.

The Effect upon the Output and Costs of the Generating Station.—There is very little necessity to enlarge upon the beneficial effects, from a financial point of view, upon the works costs of the generating station, of a good day load in the form of a demand for electric motive power. The reader is referred to the section on "How to charge for Electrical Energy," wherein is set out in considerable detail the items which make up the cost of production. It is there shown that the rate of charge for electricity is dependent upon the average number of hours per day during which the demand is required. By reference to Tables V. and VI., it will be seen that the longer a given demand is used daily, the cheaper the rate of charge becomes to the consumer. This is true under all circumstances, no matter whether the supply is for lighting, power, heating, or other purposes. It can be readily understood that in many cases electric motors may be required for a very short time per day; such cases, for instance, as coffee-grinding, hair-brushing, restaurant lifts, &c. It is found in practice, however, that the rate of charge which has to be made for electricity for lighting purposes, may be considerably modified in regard to motive power. This arises of course from the fact that electric motors are in use principally and to a greater extent in the daytime, whereas the demand for the electric light forms the well-known "peak" at the time of dusk, when the sum of all the demands is simultaneous. It is often stated that during the winter months the respective sums of the demands for both lighting and power are also simultaneous, thereby necessitating the same initial charge per unit for the first hour's average daily demand in both cases. As a matter of experience and observation it is found that such is not the case entirely. A certain proportion of the power for motors is bound to overlap the maximum of the lighting load, but the greater proportion undoubtedly occurs before 5 p.m. throughout the year.

In Bradford, the maximum charge for motive power is $2\frac{1}{2}$d. per

unit, with the sliding scale, as in Table XVIII., reducing the price according to the average daily use. The calculations are based upon a working year of 300 days. Demand Indicators are used to ascertain the maximum horse-power, which serves the double purpose of also showing whether the consumer's motor has been applied to work beyond the capacity for which it was designed.

In addition to, and consequent upon, the effect which the demand for motive power has upon the output and generating costs of the electricity works, there are sundry advantages from a generating point of view which have not yet been taken into consideration. There is less necessity for "banking" boiler fires, as the boilers are in more general use. This reduces the quantity of coal per unit sold, and in one municipal electricity works the saving effected in three years was $\frac{1}{4}$d. per unit, the cost being reduced from $\frac{1}{2}$d. to $\frac{1}{4}$d. The radiation losses, due to keeping steam pipes warm all day, will remain practically the same, but per unit sold will of course be less with a day load than without. Another important effect occurs with the more continual running of the engines. The extra wear and tear will be negligible, indeed an advantage will accrue from their more frequent use. With an electric lighting load only, the greater portion of central station machinery is standing idle for long periods during the summer months, which, from an engineering point of view, is even more deleterious than continual running. Standing machinery has a tendency to become rusty, and in order to avoid this, each set has to be run for a few hours weekly with no load. The same applies to the generators, damp and dust doing greater harm than when they are frequently in use.

SECTION V.

HIRING-OUT OF MOTORS, ARC LAMPS, AND OTHER APPARATUS.

The hiring-out of electric motors and other apparatus is an innovation of very recent growth in connection with municipal electricity supply. The scheme was first put into operation in November 1896, by the Bradford Corporation, who were also the first municipality to own an electricity supply station. The movement is, of course, merely a corresponding enterprise to the letting out on hire of gas stoves, which, not only every municipality owning a gas works, but also every gas company, knows to be a sound and valuable commercial arrangement. It is true that there must be but a very few, if any, instances in which gas engines are let on hire, and the reasons are palpable. They are cumbersome, heavy, and complicated machines. They occupy considerable space, and cannot conveniently be stored. They consist of many parts, which have to be separately conveyed to the place of erection, and the engine then built up. They cannot be sub-divided into a number of small engines for direct coupling, as in the case of electric motors, and their operation requires skilled attendance and involves comparatively frequent overhauling. The chief reason, however, why gas engines are not more extensively let out on hire is, undoubtedly, the fact that the necessity for developing business in this direction has not been felt, nor is it likely to be. Even with regard to electric motors, the matter of selling so many more units is not in itself nearly so important as the time of the day during which those units are sold. It

is the "day load," however comparatively small, which is such a beneficial factor in the economical production of electricity. In the case of gas, this factor is practically negligible, owing to the immense superiority of storage possibilities. In addition to this, the gas stove is an admirable subsidiary in the business of gas supply, for it is as much more efficient than an electric stove for cooking purposes, as the electric motor is superior to the gas engine for power purposes. Up to such a point, gas and electricity seem to stand pretty much on an equal footing, considered as business enterprises. But in one respect, municipalities possess an important privilege in connection with gas undertakings. For the purpose of purchasing gas stoves to let out on hire, a Local Authority has power to borrow money. Up to the present time the Local Government Board have refused to sanction similar borrowing powers for purchasing electric motors for hire. The reasons have been already given in Section II., to which, therefore, we refer the reader. As an expedient, however, the necessary capital can be raised by a rate, which could be redeemed when, at some future time, perhaps, borrowing powers may be granted.

The advantages of the electric motor have already been fully dealt with in the preceding section, and hence we have now to deal only with the reasons for encouraging the wider and more rapid adoption of electricity generally, and electric power in particular. Such reasons will apply equally to motors, arc lamps, and any other piece of apparatus considered useful to the supply. The claims herein set forward have been substantiated by two years of actual experience in connection with the Bradford Corporation Works. The extent to which it has grown will be seen in the tables and references given.

Bradford has the advantage of a three-wire continuous current system of electricity supply, with potentials of 230 volts on each side of the system respectively. Motors can therefore be wound for either 230 volts or 460 volts. Arc lamps are arranged to burn two or four in series on 230 volts, and heating and cooking apparatus is designed for 230 volts.

It is often asked what are the obstacles which stand in the way of the more general adoption of electric motors and electric lighting. These, upon investigation, will be found to be one or more of the following, viz. :—

1. The extreme aversion to innovations which characterise the industrial world, in this country especially.

2. The existence of other motors in good working condition, such as steam, gas, oil, and hydraulic engines.

3. The unsuitability of high periodicity single-phase alternating currents of electricity, for motive-power purposes.

4. The want of capital to lay out in new machinery or apparatus.

5. The want of confidence in the electric motor by the non-technical manufacturer.

The first and last of these are very often overcome by the hire-system. The incentive to give a new article or method a trial, is generally created where the risk of failure is reduced to a minimum, and the pecuniary consideration is small. This has been exactly the experience in Bradford, where it was found that after both motors and arc lamps had been let on hire for six months, in many cases offers were made to the Corporation by the users to purchase the apparatus outright. It will also be seen, by reference to Tables XIX. and XX., how rapid has been the increase in the demand for motors and arc lamps. The most probable explanation in this case is that the singularly appropriate form of supply has created the demand. The advantages of these particularly efficient classes of apparatus have soon been appreciated, with the result that ordinary business competition has rendered their adoption absolutely necessary. With regard to the second of the obstacles given above, it is only a question of time, for, of course, existing motors, sooner or later, will have to be replaced. An instance which recently occurred in Bradford may be of interest. A small manufacturer had a breakdown with his gas engine. He applied immediately for an electric motor on hire from the Corporation. He was informed that he could not be supplied, as his workshop was a

considerable distance from the corporation supply mains. At first he threatened to have his gas engine repaired, but found that this did not have the desired effect. Shortly afterwards another application was made by the same individual, for an electric motor, for premises adjacent to the existing mains. He had decided to remove from his original premises and to extend his works for the sake of driving by electricity.

Where the power to purchase exists, the buyer will probably have little or no experience, or knowledge of electrical matters, to guide him

TABLE XIX.—*Motors.*

Year	Number of Motors supplied from Corporation Mains		Total	Board of Trade Units sold per Annum
	Owned by Consumer — Not on Hire	Owned by Corporation — On Hire		
1895	35	*Nil.*	35	35,919
1896	58	7	65	54,972
1897	72	46	118	117,176
1898	99	122	221	218,974

in his purchase. If his means are at all limited he will be tempted to venture on a cheap line, and become the dupe of those who simply make to sell. The solution of these difficulties, which appears the most satisfactory, because it is the one fraught with the greatest advantages to all concerned, is that the owners of electricity supply undertakings, whether a public company, municipality, or other local authority, should themselves purchase good reliable motors, &c., and

let them out on hire. Antecedently this scheme may appear a sort of parental *regime*, but it is suited to present circumstances, at any rate, and experience proves it to work well.

TABLE XX.—*Arc Lamps.*

Year	Number of Arc Lamps supplied from Corporation Mains	
	Owned by Consumer — Not on Hire	Owned by Corporation — On Hire
1889	50	...
1890	94	...
1891	151	...
1892	219	...
1893	280	...
1894	332	...
1895	382	...
1896	454	14 (From 1st November)
1897	483	80
1898	535	186
	Total = 721	

From Table XIX it will be seen that the increase in electricity supplied for motive power in 1896, in which year the hire system had

been in operation for *two months only*, was 19,053 units; in 1897 the increased sale over 1896 was 52,204 units; and at December 31, 1898, the increase was 101,798 units, or a sale of 218,974 units, or 86 per cent. over 1897.

Conditions upon which Electric Motors are let on Hire by the Bradford Corporation:—

1. The rent is due in advance on the 1st January and 1st July in each year, the first payment to be made at the time of signing the agreement, and before the motor is connected to the corporation mains. In the event of the accounts for hire or for current becoming overdue the supply will be cut off.

2. The rent will not include the conveyance of the motor from the corporation stores to the premises of the hirer. Estimates of this cost, which must also be paid by the hirer at the time of signing the Agreement, can be obtained upon application at the Town Hall office.

3. The hirer must also provide suitable foundations (timber being usually sufficient) upon which the motor will be secured by the Corporation. Sizes of foundations for the different sizes of machines may be obtained at the offices.

4. The rent includes supplying and fixing the necessary starting switch, but all other accessories such as oil, carbon tips, special pulleys, &c., must be paid for by the hirer, and obtained from the Corporation Stores, Bolton Road. The fortnightly inspection by an authorised Inspector (who will be in uniform), will be free of charge.

5. The necessary wiring from the corporation terminal-box to the motor, including cut-outs, main switches, &c., must be provided by the hirer, and will be subject to the same conditions and tests as apply to wiring for the electric light. The meter must, in all cases, be fixed adjacent to the service terminal-boxes.

6. The supply of the motor and the current will also be subject to the Board of Trade regulations relating to electricity supply; to the rules and regulations of the electricity department of the Corporation; and the Electric Lighting Acts, 1882—1889.

TABLE XXI.—*Rent and Particulars.*

MOTORS.

Horse-Power	Speed	Diameter of Pulleys	Volts	Ampères	Rent per Annum
					£ s. d.
½ B.H.P. ...	1,700	4 inches	230	2	1 10 0
1 „ ...	1,450	4 „	230	3½	2 0 0
2 „ ...	1,200	5 „	230	6½	2 10 0
3 „ ...	1,100	5 „	230	9½	3 0 0
4½ „ ...	1,000	6 „	230	14½	4 0 0
6 „ (if in Stock)	800	7 „	230	19	5 0 0
7 „ ...	800	7 „	230	22½	6 0 0
10 „ ...	800	10 „	230	32	8 0 0

Conditions under which Arc Lamps are let on Hire by the Bradford Corporation :—

1. The rent is due in advance on the 1st January and 1st July in each year, the first payment to be made at the time of signing the agreement, and before the arc lamps are connected to the corporation mains. In the event of the accounts for hire or for current becoming overdue, the supply will be cut off.

2. The rent will not include fixing the lamps on the premises of the hirer. The cost of this may be ascertained on application at the Town Hall offices. The hirer must also provide and fix in position the necessary hooks or brackets on which the lamps are to be placed, and a sufficient length of electric cable must be left at the brackets to enable the lamps to be connected up.

3. The lamps will be supplied complete with globes and resistances,

and will be left in satisfactory working order. In the event of any globe being broken, or any terminal or portion of the lamp becoming burnt, the hirer must pay the cost of replacing the defective part. These defects and breakages must be remedied with the least possible delay.

4. The rent includes periodical inspection by an Inspector in uniform, whose duty it is to report upon the condition of the lamps and installation.

5. A separate meter must be placed in the arc light circuit, in the event of there being also incandescent lamps in the same installation.

6. The necessary wiring from the corporation terminal-box to the arc lamps, including cut-outs, main switches, &c., must be provided by the hirer, and will be subject to the same conditions and tests as apply to other installation wiring.

7. Under no circumstances is the seal of the corporation on the lamps to be broken or interfered with by the user. Notice of any irregularity must be given at the offices.

8. The supply of the arc lamps and the current will also be subject to the Board of Trade regulations relating to electricity supply; to the rules and regulations of the electricity department of the Corporation; and the Electric Lighting Acts of 1882—1889.

PRICES AND SIZES OF CARBONS.

SIZES			PRICES
12 millimetres and	12 millimetres	(for enclosed arcs) ...	3d. per pair.
18 ,,	11 ,,	... ...	1¾d. ,,
12 ,,	7 ,,	... ...	1d. ,,

These carbons are of the best quality only, inferior carbons are likely to give dissatisfaction and trouble.

N.B.—Prices for other items for repairs and renewals, such as inner globes, &c., may be obtained on application at the show room or offices.

TABLE XXII.—*Rent and Particulars.*

ARC LAMPS.

Type	No. in Series	Ampères	Approximate Candle-power of each Lamp	Rent per Annum	Total Cost per Hour for Current
Enclosed Arc (if in stock) (Single Carbon)	2	5 to 6	500	£1 1 0 each	5d.
Open Arc ... ... (Double Carbon)	2	5 to 6	500	£1 1 0 „	5d.
Open Arc ... ... (Double Carbon)	2	10 to 12	1,000	£1 1 0 „	10d.
Open Arc ... ... (Single Carbon)	4	5 to 6	500	£0 10 6 „	5d.
Open Arc ... ... (Single Carbon)	4	10 to 12	1,000	£0 10 6 „	10d.

The enclosed type arc lamp requires re-carboning only once every 100 hours.

The following form of agreement is the one adopted by the Bradford Corporation for the letting on hire of both motors and arc lamps :—

CITY OF BRADFORD. ELECTRICITY DEPARTMENT.

No............

Agreement.

6d.
STAMP

The undersigned

of

(herein called the hirer), hereby agrees to take on hire

No. the property of the Mayor, Aldermen, and Citizens of

the City of Bradford (herein called the Corporation), upon the following conditions :—

1. The hirer shall pay to the Corporation for the hire and renting of the said goods, at the rate of pounds, shillings, and pence per annum, payable half-yearly in advance, on the 1st July, and the 1st January in each year, the first payment to be made on the signing of this agreement.

2. The hirer shall prudently and properly use and keep the said goods in good order and clean condition, save reasonable wear and tear, and shall use the same only at the premises above-named within the said City, and shall not remove or suffer the same to be removed therefrom, except with the express leave, in writing, first obtained for that purpose from the engineer for the time being of the Corporation ; nor do, or suffer anything to be done, whereby the said goods may be distrained, seized, attached, or taken into execution.

3. If the said goods be improperly or negligently used, the hirer shall be liable to the Corporation for the damage thereof incurred.

4. The plate stating that the goods are the property of the Corporation shall not be altered or removed.

5. If the hirer shall fail to make any of the said payments, as and when the same shall become due, or shall fail to keep the conditions herein contained, it shall be lawful for the Corporation to take possession of, and remove the said goods, and for that purpose to enter any building in which the same may be contained without being liable to any action or claim in respect thereof, or for any loss or damage occasioned thereby.

6. Nothing herein contained shall be understood or construed to vest in the hirer any title to the said goods, otherwise than as hirer thereof.

Dated this day of 189

Signed,

Witness,

Basis of Charge.—The basis upon which the annual charge for hire should be made is arrived at by adding all the charges consequent upon the capital outlay. These are :—

1. Interest.
2. Sinking fund.
3. Depreciation and repairs.

The interest may be taken as an average of 3 per cent. per annum. The sinking fund will be variable according to the period over which the capital is borrowed. Usually this is twenty-five years, and the amortization is practically equivalent to another 3 per cent. per annum. The rate for depreciation and repairs will depend upon the nature of the apparatus on loan. For motors and arc lamps the "life" may be reckoned as ten years, and the repairs at the rate of 4 per cent. per annum. This gives a total rate for depreciation, &c., of 14 per cent. per annum. Hence the total charge should be :—

Interest	3	per cent.	per annum.
Sinking fund...	3	,,	,,
Depreciation, &c.	14	,,	,,
Total	**20**	,,	,,

Therefore 20 per cent. of the capital outlay should be the annual rental charge. In Bradford, as will be seen in the Table of Rent and Particulars already given, only 10 per cent. is charged. The 10 per cent. for actual depreciation has been taken out of the annual rental, and allowed for in the price charged per unit. By this arrangement it was considered that greater inducement would be offered to adopt the apparatus on hire.

This department may also, with advantage, undertake the sale of such articles as are required for the use and operation of the apparatus on hire. For motors—oil, carbon brushes, &c., should be sold ; and for arc lamps—carbons and globes.

The following rules, printed on stout card or strawboard, should

be supplied with each motor and hung up in a convenient place adjacent to it.

Directions to be observed to ensure the safe and satisfactory working of Electric Motors :—

1. The motor must never be started with the load on.

2. The motor must always be started and stopped by the starting switch. The main switches may be left *open* when the premises are not occupied, but they must always be *closed* before starting the motor.

3. If the starting switch is in order, the speed of the motor will be slow on first closing the circuit, but full speed will be attained after five to ten seconds. It must not be used until full speed has been attained.

4. If the motor appears to start up too rapidly, notice should at once be sent to the Electricity Office, Town Hall, as the motor may be damaged if the defect is not remedied.

5. If the motor starts up too rapidly or with the load on, the main fuse will probably be blown.

6. Before starting, see that the oiling arrangements are satisfactory; oil should not be allowed to run on the bearings when the premises are closed.

7. Suitable oil may be obtained at the stores, Bolton Road Electricity Works. Price 2s. per gallon, payable in advance at the Electricity Office, Town Hall.

8. The brushes (*i.e.* the carbon contacts on the commutator) must not be lifted, under any circumstances. If the carbon has worn down too low, which may be ascertained by the loud scratching noise which the holders make on the commutator, new carbons should be at once put in, and the attention of the Inspector called to the matter, or notice sent to the Town Hall. Neglect of the above will cause scoring of the commutator, and will damage the machine.

9. The Inspector, who will be in uniform, will examine the motor periodically, and you are requested to allow him to start and stop the motor and to make what examination he thinks necessary.

10. The motor should not be left running when not in use; observance of this will tend towards considerable economy.

11. Irresponsible persons, or those unacquainted with electric motors, should not be permitted to do anything whatever in the nature of a repair or adjustment under any circumstances. Attention will always be given to irregularities on notification at the office at the Town Hall, or in writing.

Almost every town, with any pretension to size and importance, has its own large staple industries, as well as many minor industries and businesses, requiring the use of other power than hand power. There are also some handicrafts and operations which are at present unavoidably confined to hand power, because steam, gas, oil, and hydraulic power, are each and all inapplicable. There can be little doubt that the electric motor would be welcomed and readily adopted in these cases, if only its simplicity and adaptability were known and understood.

The following is a somewhat full though by no means exhaustive list of these trades and purposes :—Acid making, ærated bread making, ærated water manufacture, agricultural implement manufacture, back and vat making, bag making, basket making, beer bottling, cycle making and repairing, blowers for foundry work, boiler making, bookbinding, boot making, boot polishing, bottle cleaning, bottle making, box making, brass finishing, brush making, cabinet making, carpenters' machinery, carpet beating, cloth-folding and cuttling machinery, coach building, coffee grinding, coopers' machinery, cutlers' machinery, crane working, dairy produce machinery, dental engines, electric signs, electro-plating, engineering, engraving, driving fans for ventilating and other purposes, forage cutting machinery, driving forced draught apparatus, founders' plant, grain elevators, hoists, hair-brushing machinery, hotel kitchen purposes, laundry machinery, driving lifts, lithographic printing plant, millwrights' plant, musical instrument making, oil refining, opticians' plant, organ building, organ blowing, packing case making, paper making, pianoforte making, picture frame making, driving press pumps, presses, printing machinery, pumping, racket making, rope making, sack making,

saddle, &c., making, sausage making, saw making, saw mill machinery, scientific instrument making, seed crushing, driving sewing machines, shop fitters' plant, smallware manufacture, smelting, smiths' plant, snuff manufacture, soap making, stick making, stuff manufacture, sugar refining, surgical instrument making, theatrical machinery, timber cutting machinery, tin plate working, tobacco cutting, tool making, toy making, turning, twining (lathe work), umbrella making, undertaking, watch making, wheat grinding, wire working and drawing, wood-working machinery, wool-comb machinery, zinc working, &c., &c. Other special and local industries will occur to the reader, without enumeration, which can be placed in the same category.

Insurance.—There is still a considerable difference of opinion among both the fire insurance companies and electrical engineers, as to what should form a proper and efficient covering or casing for electric motors, starting switches, and other apparatus connected therewith, in order to minimise the risk of fire resulting from sparking, short-circuiting, or fuse-blowing. The insurance companies, who never lose an opportunity of increasing, if possible, the insurance rate, and who are largely governed in this matter by a general fire offices committee, have at present decided that a casing or covering of iron is compulsory. It can be readily understood, however, by electrical engineers, that such a covering, if made with sheet iron and without due regard to details, may in itself, constitute a serious source of danger. In fact, a loose metal case or a detachable iron cover is to be strongly condemned.

The necessity (which, after all, undoubtedly exists) for protecting the motor from injury, for keeping it clean, and for complying with insurance requirements, has led to the design of so-called enclosed or iron-clad motors, in which the electrical windings, the commutator, brushes, &c., are enclosed in an iron casting which forms part of the machine itself. The only working portion of the machine which should be exposed is the fly-wheel (if any) and the pulley.

Illustrations of various types of enclosed motors are shown in Fig. 9.

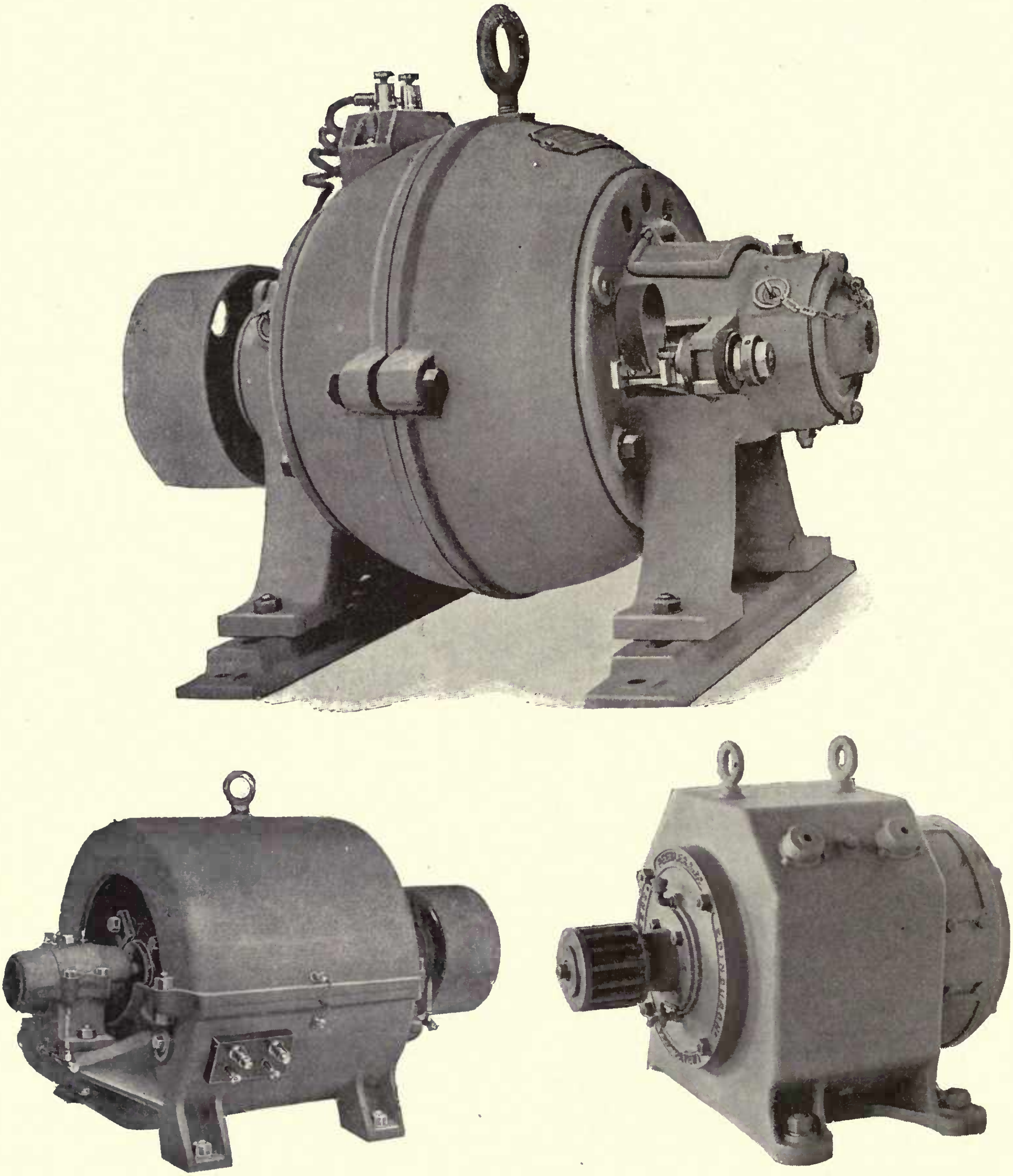


Fig. 9.

Method and System of Storekeeping for a Hiring-Out Department.—When an application is made for a motor, arc lamps, or other apparatus on hire, sundry material, in addition to the apparatus itself, will be required. This material will probably consist of wire and casing for connecting motor and starting switch, or the arc lamps and meter, meter brackets, screws, holding-down bolts, emery paper, oil, carbons, solder, wire terminals and sockets, insulating tape and compounds, varnish, and many such items. As it is impossible to estimate exact quantities required, no more and no less, some of these, when the work is completed, will be again returned into stores, and hence a proper system of checking the quantities used is absolutely necessary. The foreman or inspector who has charge of the work, should make out a requisition on the stores in a book of which every leaf is numbered and which has a counterfoil so that a duplicate entry can be made. This requisition sheet should contain the order number of the particular installation for which the material is required. It is then duly signed, detached, and handed to the storekeeper. After the goods have been handed out the particulars are entered up from these forms into the usual books, kept in the stores, and the material *debited* to the particular order numbers respectively. When the unused material is returned to the stores, a similar ticket should be made out by the foreman, and plainly marked that the goods are to be *credited* to the order number of the work from which they are returned, such material being, of course, *debited* to stock again. It may, perhaps, be found advisable that different books should be used for this purpose, and that the "*debit*" and "*credit*" tickets should be of different colours, so as to avoid as far as possible any mistakes in entry.

The following is a description of the method of book-keeping adopted by the Bradford Corporation for the hiring-out departments, together with illustrations of the forms used. When the goods, *i.e.*, motors and arc lamps, are received from the makers, they are first of all examined and tested and then entered into the ordinary stores books as having been received into stock. Each article is given a Corporation

number, the numbering being progressive, and a brass label bearing the assigned number (Fig. 10), is attached to each. When the invoices for the goods are sent in, the description and particulars, together with the Corporation number, are entered into the stock book of the hiring-out department. It must be remembered that these books are separate and distinct from those kept in the stores department, although the goods are taken into the general stores, and are also entered into the books there. When a customer makes an application for goods on hire, the particulars on the application form are entered into a book with a detachable form and a counterfoil. The form is illustrated in Fig. 11. The detached form is first sent to the mains department,

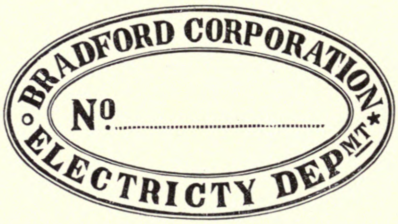


Fig. 10.

and when the work has been completed there, it is forwarded to the meter department. These forms are subsequently returned to the general office, where any additional charges are made in the form of an account against the hirer. From the application form also the particulars are entered into a rough book from which notification is sent to the storekeeper that certain articles are wanted, but before sending them out he receives a written notice from the hiring department, stating that the hirer has signed the agreement and paid the hire. A duplicate form of delivery note is sent by the storekeeper to the hiring department, and signed jointly by himself and the assistant electrical engineer. When the apparatus on hire has been fixed, a form called "Outwards" is sent by the motor and arc lamp department to the hiring

No...............

CITY OF BRADFORD.

ELECTRICITY OFFICE, TOWN HALL.

Works Order for Mains & Meters Department.

PARTICULARS FOR THE SUPPLY OF ELECTRICITY

To the Undernamed Premises.

Date....................................189

M..

Address..

Situation of Premises to be supplied.................................

INCANDESCENT LAMPS.

	No.	C.P.	Amps.	No.	C.P.	Amps.
Applied for.	....	....	....	....	....	....
	....	....	....	....	....	....

ARC LAMPS.

	No.	Amps.	In series.	Type.
On Hire.	....	....	....	....
	....	....	....	....

MOTORS.

	No.	B.H.P.	Amps.	Type.
On Hire.	....	....	....	....
	....	....	....	....

Remarks..

Signed..
Chief Clerk.

THIS FORM TO BE FILLED UP AND SIGNED, AND TO BE RETURNED TO THE OFFICES, TOWN HALL, DAILY.

No...............

CITY OF BRADFORD.

ELECTRICITY OFFICE, TOWN HALL,....................................189

WORKS ORDER FOR MAINS & METERS DEPARTMENT.

PARTICULARS FOR THE SUPPLY OF ELECTRICITY

To the Undernamed Premises.

M..

Address..

Situation of Premises to be supplied..................... Description of Premises................

INCANDESCENT LAMPS.

	No.	C.P.	Amps.	No.	C.P.	Amps.
Applied for.	....	....	....	....	....	....
	....	....	....	....	....	....
In-stalled	....	....	....	....	....	....
	....	....	....	....	....	....

ARC LAMPS.

	No.	Amps.	In series.	Type.
On Hire.	....	....	....	....
	....	....	....	....

MOTORS.

	No.	B.H.P.	Amps.	Type.
On Hire.	....	....	....	....
	....	....	....	....

Sizes and details of Wire to be used on premises..
Reference Nos. on Sample Board.............. Wiring Contractor.............................

Signed..*Chief Clerk.*

Particulars.—Mains Dept.

Total Feet of Cable..............................
Feet of Cable on Premises ... }..............................
Wood boxes.. .... Brass Ends..........
Indiarubber Sleeves..............................
TIME: Jointers.......hrs. Labourers.......hrs.
Remarks..............................
....
....

Signed..............................
Chief of Mains Department.

Particulars.—Meters, &c., Dept.

Date Tested............. By whom............
Insulation Resistance......... Polarity.........
Date connected .... By whom............
Remarks..............................
Meter Bracket..............................
Shunt Wire............yds. Casing............ft.
TIME: Carpenter.....hrs. Labourer......hrs.
Remarks..............................
....

Signed..............................
Chief of Meters Department.

(N.B.—The actual forms should be about twice the above size.)

FIG. 11

ROUGH BOOK.

MOTORS ON HIRE.

Prog. No. in Hire Book	Date of Application	Name and Address	Size of Motor	Maker's Number	Date when Connected	Corporation Number		Maker's Name	Remarks
						Motor	Starter		

APPARATUS

CITY OF BRADFORD.

Prog. No.	Date when Hired	Corporation Numbers		Occupier	Situation of Motors and Arc Lamps	Description		
		Motors and Arc Lamps	Starter and Resistances			Apparatus	Maker's Number	Name of Maker

RENTAL

CORPORATION OF BRADFORD.—ELECTRICITY FUND.

Particulars of Electrical Apparatus					Annual Charge for Hire being 10 per Cent. on Cost	Prog. No. in Rental Book	Corporation Hire Number		By whom
Maker's Number	Name of Maker	Date when Hired		Cost			Motors and Arc Lamps	Starter and Resistances	Name
		Month	Year						

STOCK

MOTORS,

Prog. No.	Date when Received	From whom	Mark or Number	Description

Fig. 12.

ROUGH BOOK.

ARC LAMPS ON HIRE.

Prog. No. in Hire Book	Date of Application	Name and Address	Number of Lamps Hired	Maker's Number	Date when Connected	Corporation Number		Maker's Name	Remarks
						Arc Lamps	Resist-ance		

ON HIRE.

MOTORS, ARC LAMPS, &c., ON HIRE.

Selling Price	Annual Charge	Remarks as to Removals and Transfers	Corporation Numbers		Date Returned to Stores	Remarks as to Return of Motors, &c., into Stores
			Motors and Arc Lamps	Starter and Resist-ances		

BOOK.

HIRED ELECTRICAL APPARATUS RENTAL, 189

Hired	Amount Charged for Half-year Ending June 30	Amount Received		Date and Folio in Cash Book	Amount Charged for Half-year Ending Dec. 31.	Amount Received		Date and Folio in Cash Book	Remarks
Situation of Electrical Apparatus		Current A/c.	Out-standing			Current A/c.	Out-Standing		

BOOK.

ARC LAMPS, &c.

List Price	Rate of Discount	Net Amounts	How Disposed of				
			Cash Sales		Credit Sales		On Hire
			Prog. No.	Amount	Prog. No.	Amount	Prog. No.

FIG. 12 *(continued)*.

CITY OF BRADFORD—ELECTRICITY DEPT.

DAILY REPORT

Of Motors, Arc Lamps & Accessories on Hire.

OUTWARDS.

.... *189*

To Mr. ....

Please note that the following ....
were [was] installed on above date.

MOTORS.

Maker ....
Mark or No. ....
Styled ....
Size.............. B.H.P. ....
Corporation Hire No. ....
Amps.................. Volts...........

STARTER.

Maker...................................
Type ....
Corporation Hire No. ....

Remarks ....

ARC LAMPS.

Maker ....
Mark or Nos. ....
....
Styled ....
Corporation Hire Nos. ....
....
Amps............. Volts.............

RESISTANCE.

Maker ....
Type ....
Corporation Hire Nos. ....
....

Remarks ....

By whom fixed ....
Name of Hirer ....
Address ....
Signed ....

HIRE BOOK FO. ....

CITY OF BRADFORD—ELECTRICITY DEPT.

DAILY REPORT

Of Motors, Arc Lamps & Accessories on Hire.

OUTWARDS.

.... *189*

To Mr. ....

Please note that the following ....
were [was] installed on above date.

MOTORS.

Maker ....
Mark or No. ....
Styled ....
Size.............. B.H.P. ....
Corporation Hire No. ....
Amps............. Volts..............

STARTER.

Maker...................................
Type ....
Corporation Hire No. ....

Remarks ....

ARC LAMPS.

Maker ....
Mark or Nos. ....
....
Styled ....
Corporation Hire Nos. ....
....
Amps............. Volts.............

RESISTANCE.

Maker ....
Type ....
Corporation Hire Nos. ....
....

Remarks ....

By whom fixed ....
Name of Hirer ....
Address ....
Signed ....

FIG. 12 *(continued).*

CITY OF BRADFORD—ELECTRICITY DEPT.

DAILY REPORT

Of Motors, Arc Lamps & Accessories on Hire.

INWARDS.

....*189*

To Mr...

Please note that the following..............................
were [was] Removed on above date.

MOTORS.

Maker ....
Mark or No. ....
Styled ....
Size.............. B.H.P..... ....
Corporation Hire No. ....
Amps..................... Volts..........

STARTER.

Maker..................................
Type ....
Corporation Hire No............
Why Removed ....
Remarks.................................

ARC LAMPS.

Maker..................................
Mark or Nos. ....
.. ..
Styled..................................
Corporation Hire Nos. ....
....
Amps. .... Volts..........

RESISTANCE.

Maker ....
Type.....................................
Corporation Hire Nos. ....
....
Why Removed........................
Remarks ....

By whom Removed..
Name of Hirer...
Address...
Signed..

HIRE BOOK FO....................

CIT F BRADFORD—ELECTRICITY DEPT.

DAILY REPORT

Of Motors, Arc Lamps & Accessories on Hire.

INWARDS.

....*189*

To Mr...

Please note that the following..............................
were [was] Removed on above date.

MOTORS.

Maker ....
Mark or No. ....
Styled ....
Size..................B.H.P............
Corporation Hire No. ....
Amps.................... Volts.........

STARTER.

Maker ....
Type ....
Corporation Hire No. ....
Why Removed ....
Remarks ....

ARC LAMPS.

Maker ....
Mark or Nos. ....
....
Styled ....
Corporation Hire Nos. ....
....
Amps................ Volts..........

RESISTANCE.

Maker ....
Type.....................................
Corporation Hire Nos.........
....
Why Removed ....
Remarks.................................

By whom Removed..
Name of Hirer...
Address...
Signed..

FIG. 12 *(continued)*.

CASH SALES BOOK.

1 MOTORS, ARC LAMPS, &c. CASH SALES. 1

Prog. No.	Date	Name and Address	Prog. No. in Stock Book	Prog. No. in Stock Book if returned	Mark or No.	Description	Amount £ s. d.	Counter-foil Receipt No.	Remarks

CREDIT SALES BOOK.

1 MOTORS, ARC LAMPS, &c. CREDIT SALES. 1

Prog. No.	Date	Name and Address	Prog. No. in Stock Book	Prog. No. in Stock Book if returned	Mark or No.	Description	Amount £ s. d.	Ledger Folio	Remarks

SUNDRY SALES BOOK.

DAY BOOK.

Cash Book Folio	Particulars	Rate	£ s. d.	£ s. d.

FIG. 13.

B. C. E. W.

MOTORS—OUTWARDS.

Corpn. No............... *Maker's No.*............ *Amps*.............. *B.H.P.*..............

Maker.. *Type*..

Page in Test Book.......................

I hereby certify that I have examined and tested this Motor and find it to be in good condition.

(Signed)..

Date........................*189*

This form to be attached to Motor before it is issued.

FACE (Blue Card).

B. C. E. W.

Motor fixed at

Name..

Address ....

....

Date..............................*189* *By*..

This Form to be filled in by Motor Fixer and returned to Motor Department.

Noted

(Signed)...

BACK (Blue Card).

FIG. 14.

B. C. E. W.

MOTORS—INWARDS.

Motor No. .... *Amps* .... *B.H.P.* .... *Maker* ....

Type ....

Removed from *Cause of Removal* ....

Name ....

Address ....

Date .... *189* *By* ....

This Form to be fixed to Motor at time of Removal.
The Motor to be returned to Motor Department.

FACE (Yellow Card).

B. C. E. W.

I hereby certify that I have examined and tested this Motor and find it to be in .... *condition.*

(If in bad condition, state defect below.)

....

....

....

Signed ....

Date *189*

BACK (Yellow Card).

FIG. 14 *(continued).*

B. C. E. W.

ARC LAMPS—OUTWARDS.

Corpn. No............... *Maker's No.*.............. *Amps*.............. *Volts*..............

Maker.. *Type*..

To burn.................... *in series.* *Page in Test Book*..............................

I hereby certify that I have examined and tested this Arc Lamp and find it to be in good condition.

(Signed)..

Date.............................. *189*

This Form to be attached to Arc Lamp before it is issued.

FACE (Green Card).

B. C. E. W.

Arc Lamp fixed at

Name..

Address..

....

Date.............................. *189* *By*..

This Form to be filled in by Arc Lamp Fixer and Returned to Arc Lamp Department.

Noted

(Signed)..

BACK (Green Card).

FIG. 14 *(continued).*

B. C. E. W.

ARC LAMPS—INWARDS.

Corpn. No..................*Maker's No*...............*Amps*............ *Volts*..............

Maker.......................................*Type*................ *To burn*................*in series.*

Removed from *Cause of Removal*..

Name..

Address...

Date..........................*189* *By*..

This Form to be fixed to Arc Lamp at time of Removal.
The Arc Lamp to be returned to Arc Lamp Department.

FACE (Red Card).

B. C. E. W.

I hereby certify that I have examined and tested this Arc Lamp and find it to be in.....................*condition.*

(If in bad condition, state defect below.)

....

....

....

(Signed)

....

Date............................*189*

BACK (Red Card).

FIG. 14 *(continued).*

department. From this form particulars are entered into the hire book and the rental book. If, at any time, any apparatus on hire is not working satisfactorily, it is returned to the meter department for repairs, and an "Inwards" form is then sent to the hiring department. This "Inwards" form is also entered into the hire book. The rental book is re-written from the hire book at the end of every year.

Examples of these books and forms are given in Fig 12.

In some cases, as has already been explained in this Section, it is necessary to sell goods such as oil, carbons, heating apparatus, &c.; and even the motors and arc lamps on hire may be bought for cash or credit. Hence it will be seen in Fig. 12, that spaces have been left for that purpose in the stock book heading. For smaller and daily sales special books are kept, called Cash Sales Book, Credit Sales Book, and Sundry Sales Book respectively, and which are given in Fig. 13.

Examples are also given in Fig. 14 of the cards which are attached to each piece of apparatus as it leaves the Stores or Hiring Department. These cards are printed on the front and back, and the "Inwards" and the "Outwards" are in different colours.

SECTION VI.

FREE-WIRING.

THE term "Free-Wiring" means, of course, wiring free of initial cost to the customer, or in other words, wiring on the hire system.

The advantages of this arrangement, as regards both the consumer and the supply department, are similar to those already enumerated and explained in the previous section on the hiring-out of motors and arc lamps. There is this great difference, however, between the two schemes, that motors, arc lamps, heating apparatus, and similar articles are readily removable, whereas electric wiring becomes practically a fixture in the house or premises. In the first case it is possible to remove the articles from place to place when required; their value does not deteriorate as articles of commercial utility, except for a natural depreciation due to wear and tear; they may always be reckoned a negotiable asset of the business, and at some future time it is possible that the Local Government Board may deem them articles of a *"permanent nature," and grant borrowing powers to raise the necessary capital for their purchase.

In the case of wiring, however, it is impossible, inexpedient, or useless, to remove it in the event of householders or tenants discontinuing the use of electricity. It is true that as a rule fittings are supplied with the wiring, but almost the same objections apply to them also. If fittings are removable, they nevertheless deteriorate in value at a rapid rate, and the possibility of re-utilizing them in other installations is remote. Consumers, even though they may take readily to hiring their

---

* See "Borrowing Powers," Section II.

wiring, yet do not expect nor would they be satisfied with second-hand fittings. Where, therefore, both the wiring and the fittings are likely to fall back upon the hands of the Corporation, the risk of a certain amount of capital lying idle is considerable, and its effect would probably be very appreciable. The value of each installation, moreover, depreciates much more rapidly than motors and the like apparatus. Wiring and fittings do not form any asset independent of their use at the particular premises in which they are installed, and for this and the other reasons just mentioned it is, in the last degree, improbable that borrowing powers will ever be granted to a municipality for the purpose. If, however, the enterprise is in the hands of a private company, the matter assumes a different aspect. This was recognised in 1896 by the Electric Free-Wiring Syndicate, since merged in the National Electric Free-Wiring Company, Limited, and in the prospectus issued to various Corporations at that date, the syndicate stated "we are advocates of such an innovation as giving the consumer his wiring, and there is no doubt, had your Corporation, as undertakers, power to do this, such a step would pay them exceedingly well from a business point of view." It is clear from the foregoing that this is a matter which it is very much better, under present circumstances, to leave in the hands of a company than to be entered upon by a municipality. If the municipality, however, wish to have some controlling voice in the business, certain arrangements can be entered into with the National Electric Free-Wiring Company, which are described further on when dealing with the terms of hire or hire-purchase.

We now propose to consider the subject in its direct and immediate bearings only, and it will be convenient to look at it from two aspects, viz. :—

1. The position of the private householder.
2. The effect on the supply undertaking and the cost per unit.

1. *The Position of the Private Householder.*—The greatest argument in favour of free-wiring, however, as far as the private householder is concerned, is without doubt the fact that, whether he be tenant or

landlord, he is relieved from personal expense and liability. In these days of frequent change of habitation, of continual transfer of ownership of property, and of the keenest competitions in business, the ordinary householder does not feel inclined to hurriedly invest money in what is not likely to prove some sort of asset. The necessary wiring for an electric light installation, like house decoration and some other things, are certainly not "assets," nor are they in any sense portable property. The expense of such paraphernalia is always incurred more or less begrudgingly, and, with the majority of middle-class householders, there is usually a very decided limit to the outlay of money for what may truly be called expensive luxuries. On the other hand, it is a tempting offer which it is difficult to resist when any such modern improvements are to be obtained on "easy terms" involving no immediate outlay, and perhaps only a nominal rent per annum. It is true that the bill for electricity will, in many cases, exceed that which has been heretofore expended for gas or oil, but the consumer will not mind this.

Electricity has already a good foothold, and the broad general recommendations in its favour are already well known. In most towns, even at the present time, the householder has become acquainted with, if not actually used to, the advantages of the electric light in his business office or premises, in the restaurant, the club, and the theatre. In his own house, however, he has still to put up with an inferior method of illumination, which is harmful, unpleasant, and unsatisfactory. Free-wiring is therefore decidedly a boon; there is a demand for it already, and if it once becomes established within any area of electricity supply, the ratepayer in his suburban home will very speedily enjoy the same privilege as he now possibly does in his town office.

2. *The Effect on the Supply Undertaking and the Cost per Unit.*— The successful progress and development of an electricity supply undertaking, considered as a municipal enterprise, and from a financial point of view, depends to a much greater extent upon the conditions under which the supply is available, than upon the characteristics of the town and local circumstances.

It will readily be admitted that such conditions as the price of coal, wages, system of supply, character of the population, and commercial importance of the borough, are matters which are only significant when a comparison is being made with other towns, as to relative progress and development. Such circumstances, however, do not materially affect the cost of production, as may readily be ascertained upon reference to the total cost of production per unit supplied for any town where such a department has been in operation over two years.

It is a fact, and a most remarkable one, that the great majority of towns have not as yet been able to reach any lower figure for their "standing charges" rate than 2d. per unit. The peculiar feature about this apparently permanent high rate per unit for these charges is, that it remains practically the same year by year in each instance of municipal electricity supply, notwithstanding the very rapid growth of some of them. The deduction is a perfectly natural one. As the number of consumers has increased, so it has been found necessary to increase the capital expenditure, &c., in almost the same proportion. It is clear also, as a further deduction, that the *class* of consumer has remained the same, viz., the tradesman who requires his supply for a very limited time in the early portion of the evening only. That is to say, the conditions under which the supply at present is offered to the public are such as to preclude, or at any rate not to attract, the ordinary householder, or the "many-hour" consumer.

Hence the electric light is only seen in the shop of the tradesman, who can well afford to discard his gas fittings, and incur the expense of an electrical installation, in addition to paying a rate of 5d. or 6d. per unit for electricity.

Corporations have been content so far with offering slight and inadequate inducements in the form of small rebates on quarterly or half-yearly accounts, which rarely, if ever, give the satisfaction to the consumer which they are intended to give, and probably do not operate at all in securing new customers. Now, what is anticipated and claimed, as a result of the inauguration of a system of free-wiring, is this: It

would get hold of the middle-class customer—the individual who, as a rule, for many cogent reasons, will not go to the expense himself of cashiering his gas-fittings and wiring his house for electricity. He is the very consumer who is so valuable to the supply works, because he uses the light over many hours, in contradistinction to the demand of shops and business offices, which is for a few hours only. It is the "many-hour" consumer, in fact, who increases the efficiency and earning capacity of the plant.

Hence the immediate consequence is that, little by little, as these consumers are added, so the standing charges will be reduced, until ultimately, and probably very soon, these expenses would be amply covered by one penny.

A reduction of one penny per unit would in itself undoubtedly give a very great impetus to the use of electricity from public supply mains; and as the outlying districts of a large town, where the middle-class householder would find the light such a boon, always represent the greater proportion of the population, the reduction of the standing charges rate would be permanent, with a tendency to grow less instead of to increase. With free-wiring the demand would rapidly grow, and thus the extension of mains to the districts now totally without supply, would become at once rapid and exceptionally profitable.

As an objection to the policy which we have endeavoured herein to advocate, it may, perhaps, be said that it has not been found necessary in the past to encourage gas supply by means of free installations. But it must be remembered that the adoption of and confidence in gas was of much slower growth than has been the case with its sister illuminant, the electric light. And what is of far greater importance, from its inception gas was easily and efficiently stored, and the gas companies were able to produce, on a small scale, almost as cheaply and economically as when the demand became general, irrespective of the hours when it was required. Moreover, the generation of electricity, unlike gas production, forms no by-products to reduce its initial cost. The two enterprises, therefore, stand on essentially different bases, and so the

history of gas illumination can scarcely be quoted as a guide or precedent in the case of electricity.

Arrangements with Municipal Authorities.—It has already been stated in this section that there is only one company which at present undertakes the business of wiring on the hire system, viz., The National Electric Free-Wiring Company, of 8 and 10 Charing Cross Road, London, W.C. This company seeks to enter into contracts with electric lighting companies and municipalities to wire any premises and to carry out installation work generally, in any part of the area of supply for any would-be customers. The terms and conditions are embodied in the following agreement.

Agreement made this day of 189 between The National Electric Free-Wiring Company, Limited, of Charing Cross Road, in the County of London (hereinafter called "The Wiring Company") of the one part, and (hereinafter called the "Supply Company") of the other part.

Whereas the Supply Company, in accordance with the terms of a provisional order granted to them under the Electric Lighting Acts, and , have erected buildings and machinery, and have laid mains for the supply of electricity in the district defined as the area of supply under the said provisional order:

And, whereas, the Wiring Company have agreed with the Supply Company to supply those of their consumers who may apply for the same, with all the necessary wiring and fittings for their houses, upon the terms and conditions hereinafter set forth, and such supply will be of advantage to the Supply Company by increasing the demand for electricity:

It is hereby mutually agreed between the parties hereto, as follows:—

1. The Wiring Company will, when required by the Supply Company, and subject in all respects to the same conditions as under

the said provisional order are prescribed in the case of an ordinary consumer, provide and fix the necessary wires and fittings for using electricity, for lighting purposes, on the premises of any consumer within the district of the Supply Company, who has agreed to take a supply of electrical energy, for lighting purposes, from the Supply Company on the conditions as to security set forth in that behalf in the said provisional order, and will connect such wires with the meter fixed on such premises with the Supply Company, and provide and fix in and about such premises such fittings reasonably necessary for efficiently lighting the same, and adapted to the class of property to which such premises belong, as the said consumer may select from the stock of the Wiring Company kept by them for that purpose. Provided, nevertheless, that the Wiring Company shall have the option of refusing to provide such wires and fittings in any case in which, in their opinion, the security for payment therefor will be insufficient.

2. The Wiring Company will make no charge against the Supply Company or the consumer for the said wires or fittings or the work in connection therewith except as hereinafter mentioned, and the said wires and fittings shall become the property of the Supply Company, subject to the right of the Wiring Company to be paid therefor as hereinafter provided, and the Wiring Company shall be responsible for all proper and legal claims for damage or injury done by them or their agents or workmen to any premises thus wired or fitted by them, and for all claims for injuries or damage, which can be legally made against the Supply Company, in consequence of, or in connection with such wiring or fitting, and the Wiring Company shall save harmless and keep indemnified the Supply Company in respect of all such claims.

3. An agreement shall be entered into between the Supply Company and the consumer, in the form set forth in the schedule hereto, and there shall, when required by the Wiring Company, be a further agreement entered into by the landlord or owner of the premises, recognising the legal ownership of the wires and fittings by the Supply Company, as also set forth in the schedule hereto.

4. The Supply Company shall not be entitled to require the Wiring Company to execute any work on the premises of a consumer, or intending consumer, unless the Supply Company shall first have procured the execution by him, and also by the landlord or owner where so required by the Wiring Company, of such agreement or agreements as aforesaid, and if so required, produced the same to the Wiring Company, and furnished to the Wiring Company a copy thereof.

5. The Supply Company will, on the Wiring Company carrying out the said work in a proper and workmanlike manner, and providing suitable wires and fittings, render to the Wiring Company quarterly accounts, indicating the amount of electrical energy supplied to the premises on which such work has been carried out, and the amount received by the Supply Company from the consumer in respect thereof, and until such wires and fittings have been paid for, as hereinafter provided, the Supply Company will pay to the Wiring Company 1d. per Board of Trade unit for all electrical energy so supplied and paid for, provided that the minimum payment to the Wiring Company in any year shall be 1s. for each 8 candle-power lamp or its equivalent installed.

6. The Supply Company shall use all proper and reasonable efforts to secure payment by the consumer for the electrical energy so supplied to him, but in cases where they shall not be able to obtain such payment they shall not be called upon to make any payment to the Wiring Company in respect of the electrical energy so supplied and not paid for. Provided, nevertheless, that if from any source, the Supply Company shall obtain part payment, or a composition in lieu of payment therefor, then the Wiring Company shall be entitled to a *pro rata* share of the moneys so received by the Supply Company.

7. Every consumer shall have the option at or after the expiration of five years from the date of installation, of purchasing the said wires and fittings installed in his premises at the original cost price, plus 20 per cent., and less $1\frac{1}{2}$ per cent. per annum for depreciation, and such original cost shall include all expenses of general management, and the

sum so paid by the consumer shall be forthwith paid by the Supply Company to the Wiring Company, and the Supply Company shall have the option of compounding for all future payments by one single payment to the Wiring Company, calculated on the same basis, but such option shall only be exercisable by the Supply Company in respect of the whole of the wires and fittings installed by the Wiring Company in the said district.

8. Should a consumer give notice to the Supply Company that he is desirous of purchasing the wires and fittings installed upon his premises, or should the Supply Company give notice to the Wiring Company that they are desirous of compounding, as aforesaid, in respect of the whole of the wires and fittings installed by the Wiring Company in their said district, the Wiring Company shall render to the Supply Company an account of the prime cost to the Wiring Company of such wires and fittings so proposed to be dealt with, and of the work in connection therewith, and a duly authorised officer of the Supply Company shall be at liberty to examine the books of the Wiring Company for the purpose of checking such cost.

9. In case any consumer shall require fittings, other than those kept in stock by the Wiring Company for the class of property to which his premises belong, he shall on ordering the same pay the Wiring Company for the same, which shall thereupon become his property.

10. The Wiring Company shall carry out all work under this agreement in accordance with the rules and regulations of the fire insurance companies and of the Supply Company and to the satisfaction in all things of the Supply Company's engineer.

11. The Supply Company shall not be under any liability to see that any patent owned or used, or purported to be owned or used by the Wiring Company is good, valid, or subsisting, and the Wiring Company shall pay all patent dues and royalties, and shall indemnify the Supply Company from all claims and demands in respect thereof, or of any infringement of patent.

12. It shall be at the option of the Supply Company whether they do or do not exact from the consumer any extra or special payment in respect of the wires and fittings placed by the Wiring Company on his premises, but if they do exact such payment it shall not, in any case, exceed the amount payable to the Wiring Company under Clause 5 hereof.

13. The Wiring Company shall not be liable for any repairs to or maintenance of the wires and fittings, all of which, including the renewal of the lamps, shall be done by the consumer at his own expense, but the Wiring Company shall, without charge, make good all defects in materials or workmanship during a period of six months from installation.

14. The Supply Company will not, during the continuance of this agreement, make any contract with any other person or body, relative to the wiring of consumers' premises within their district, or carry out such wiring themselves without the consent, in writing, of the Wiring Company, but this provision shall not affect the right of the Supply Company to contract for the wiring of premises belonging to themselves.

15. Either the Supply Company or the Wiring Company may put an end to this agreement by giving to the other six calendar months' notice, in writing, that they do not desire to continue the same as regards the supply to any additional consumers, but such determination shall not affect the terms of this agreement as regards work then already done.

The Schedule.

AGREEMENT FOR FREE-WIRING AND FITTING.

An agreement made this day 189 between (hereinafter called "The Supply Company") of the first part, The National Electric Free-Wiring Company, Limited (hereinafter called "The Wiring Company") of the second part, and the occupier [*or* owner *or* lessee for an unexpired term of years] of the premises (hereinafter called "The Consumer") of the third part, whereby it is agreed as follows:—

1. This agreement, as between the Supply Company and the Wiring Company, is supplemental to an agreement already made between them, dated the day of 189 but the consumer shall not be in any way bound or affected by such last-mentioned agreement.

2. The Wiring Company will, in a proper manner, and in accordance with the regulations of the fire insurance companies, and free of cost to the consumer, furnish and fit up on the said premises the necessary wires and fittings for electric lighting (herinafter called "The Installation").

3. The installation shall be, and be deemed to be, the property of the Supply Company, unless and until paid for, as herinafter provided.

4. The consumer shall have the option, at or after the expiration of five years from the date of installation, of purchasing the installation on payment of the original cost price, plus 20 per cent., and less $1\frac{1}{2}$ per

cent. per annum from the date of installation for depreciation, and such original cost price shall be taken to be such price as shall be certified by the secretary or other duly authorised officer of the Supply Company. The option to purchase shall not include the main fuse switch or meter.

5. If the consumer shall require the fittings to be of a more expensive kind than those kept in stock by the Wiring Company for the class of property to which his said premises belong, he shall pay for the same in cash, and the same shall become his property.

6. Neither the Supply Company nor the Wiring Company shall be liable for any repairs to, or maintenance of the installation, but the Wiring Company shall, without charge, make good or cause to be made good, all defects in materials or workmanship during a period of six months from the date of installation.

7. The consumer shall, until purchase as aforesaid, pay quarterly to the Supply Company for the use of the installation, 1d. per Board of Trade unit, for every unit of electrical energy supplied to the said premises, and the minimum payment in any year shall be 9d. for each 8 candle-power lamp or its equivalent installed.

8. If the consumer or other occupier for the time being of the said premises shall cease to take a supply of electrical energy to the said premises from the Supply Company, or shall neglect or refuse to pay for the use of the installation, as aforesaid, the Supply Company may, at any time, enter upon the said premises and remove and take away the installation, but if they shall do any damage to the premises by such removal, they shall make good, or cause to be made good, the same.

Signature of consumer

Full name

Address

MEMORANDUM

To be signed by Landlord where Consumer is only the Occupier.

I, the undersigned, being the landlord of the above-named consumer, and being owner (or lessee for an unexpired term of years) of the said premises, hereby consent to the installation of wires and fittings in the said premises, upon the terms and conditions of the above agreement.

Signature of landlord

Full name

Address

Date

This agreement has already been entered into with the following lighting authorities :—

The London Electric Supply Corporation, Ltd.
The South London Electric Supply Corporation, Ltd.
The St. James and Pall Mall Electric Light Company, Ltd.
The Notting Hill Electric Lighting Company, Ltd.
The Vestry of the Parish of St. Leonard, Shoreditch.
The Blackheath and Greenwich District Electric Light Co., Ltd.
The British Insulated Wire Company, Ltd., for Prescot and district.
The Fleetwood and District Electric Light and Power Syndicate, Ltd.
The Corporation of Taunton.
The Corporation of Lincoln.

From the foregoing agreement it will be seen that the Free-Wiring Company practically obtain a monopoly of this particular business within the area supplied by the contracting Supply Company or municipal authority. To this agreement many electricity supply companies and corporations object, for several reasons. One of them is the monopoly already referred to; another is that they desire to do the work themselves; and a third is on behalf of the consumer, viz., that the basis of remuneration to the Free-Wiring Company, of an additional charge per unit for each unit consumed, is neither fair nor equitable. To quote a Press comment:—" The payment of rental on every unit consumed penalises to a certain extent the person who desires to possess himself of the advantages of electricity. He knows that every additional unit consumed means at least $\frac{3}{4}$d. extra payment for the use of the fittings. Assuming, however, that for mere love of economy he elects to sit in darkness, or to close his house for the whole or greater part of the year, or that he, being a landlord, has the misfortune of finding his free-wired house untenanted, he is still confronted with the minimum payment to the company of 9d. for each 8 candle-power lamp. We presume that in such an event he would deem himself a hardly-used individual. It is, of course, possible that the Corporation nndertakes this particular liability, but even so the difference comes out of the ratepayers' capacious pocket."

The Free-Wiring Company have recognised these drawbacks in some of the agreements into which they have entered with the supply undertakers, and have modified them accordingly. The places where these modifications have been made are as follows:—

1. *Wallasey Urban District Council*, which was the first agreement entered into by the Free-Wiring Syndicate, differs from the above-mentioned agreement chiefly in the fact that the Corporation pays the Free-Wiring Company $\frac{3}{4}$d. per unit for the hire of the wires and fittings, and they obtain 1d. for the same from the consumers. In this case also, the consumer and the Council have the option of purchasing the installation at the original cost price, plus 15 per cent., and less $1\frac{1}{2}$

per cent. per annum for depreciation. The Council also has the option of determining the agreement, by giving three calendar months' notice.

2. The chief variations of the agreement in *Blackpool*, which was also entered into by the Free-Wiring Syndicate, are :—That the price is fixed at $\frac{3}{4}$d. per unit, and the Syndicate agreed to provide two classes of fittings—*(a)* for houses, &c., rated below £20 ; and *(b)* for premises rated at £20 and upwards. It is also provided that the Free-Wiring Company shall open a branch in the town. There is also a clause in this agreement, stating that it is not to be construed into a monopoly of free-wiring.

3. In *Worcester*, the agreement is identical with the first above-mentioned agreement, with the exception that the payment is 1d. per unit for all electrical energy up to twelve units per 8 candle-power lamp, and for all in addition to such annual average, the sum of $\frac{1}{2}$d. per unit.

As a general principle, the Free-Wiring Company are willing to enter into similar agreements to the first-mentioned, but they also have an alternative scheme, whereby they are prepared to instal the wires and fittings for a fixed revenue per point or per lamp. In this way the revenue, not being dependent upon the amount of electricity consumed, is based upon the *cost* of the installation.

As an argument in favour of free-wiring for supply stations, it may be mentioned that, as regards *Wallasey*, the Free-Wiring Company have wired over 70 per cent. of the consumers, who use 80 per cent. of the total current supplied. With the assistance of free-wiring, this supply station has been enabled to show a profit of £800 in the first year, whereas they had estimated at the commencement that they would have to put up with a loss of £200 on the first year's work.

At *Taunton*, during the period the Free-Wiring Company have had works in operation (seven months), they have provided 1,732 lights. The additional lights added at Taunton in 1897 were only 1,500, while in 1896 the additions were only 790, and in 1895 400.

In *Fleetwood*, where the supply is not yet ready, the Free-Wiring

Company have obtained more than seventy customers, requiring 1,506·8 candle-power equivalents.

The Company are also prepared to do business on the hire-purchase system, on the following terms, viz. :—

1. The Company agrees to let on hire to the hirer, and the hirer agrees to take on hire from the Company, the wires, fittings, and apparatus for electric lighting, or heating, or power, which are more particularly specified in the schedule hereunder written, and which are hereinafter referred to as the installation. The installation shall be supplied and fitted, and kept in repair by the Company, at the Company's expense, except as mentioned in Clause 3.

2. The hirer agrees to pay the Company in advance £ every calendar month, by way of rent for the installation.

3. The hirer shall, during the hiring, do all that is necessary on his part to keep the installation in good order, and will bear the expense of all repairs rendered necessary by his default, and will also pay for the renewal of the lamps.

4. The hirer will not during the hiring sell, or offer for sale, or assign, mortgage, or underlet, or otherwise part with the possession of the installation, or any part thereof, or remove the same, or any part thereof, from the above-mentioned address of the hirer, without the previous consent in writing of the Company.

5. The hirer will during the hiring punctually pay the rent of the premises occupied by him in which the installation is affixed.

6. The hirer will during the hiring permit the Company and their agents and employés, at all reasonable hours, to enter upon the premises to inspect the condition of the installation, and to make good any defects, and to remove the installation whenever the Company shall, under the provisions of this agreement, become entitled to have possession thereof.

7. If the hirer shall desire to terminate the hiring, he shall be at liberty so to do at any time after the day of upon giving one calendar month's notice to the Company of his desire

so to do, and at the expiration of such period of one calendar month, the hiring shall be determined, and the hirer shall thereupon immediately deliver up the installation to the Company.

8. If the hirer do not pay the rent, or do not fulfil the conditions of this agreement, or if the hirer give to the Company such notice as is mentioned in Clause 7 hereof, or if a receiving order in bankruptcy is made against the hirer, or if he shall execute an assignment for the benefit of his creditors, or arrange or compound with the greater number in value of them, or if he shall suffer his effects to be distrained upon or taken in execution, or allow any judgment against him to remain unsatisfied, then and in any of the said cases the hiring shall become immediately terminable at the option of the Company, and the Company, their agents or employés, may enter upon the premises, and seize and take away the installation.

9. If the hiring is determined under either Clause 7 or 8 of this agreement, the Company may, notwithstanding the return or seizure of the installation, recover by action from the hirer, all rent payable in accordance with the terms of the agreement, and also damages for any injury to the installation, and any costs, expenses, and payments incurred or made by the Company in connection with obtaining possession of the installation; and the hirer shall not be entitled to any allowance or return in respect of rent paid, or any set-off in respect of money spent on the installation.

10. When the hirer shall have paid to the Company rents amounting in the aggregate to the sum of £ then the hirer may, upon giving to the owner notice in writing of his desire so to do, purchase the installation from the Company for the sum of £1, and on payment of such sum by the hirer, the Company will assign to him all their interest in the installation; but until such notice shall have been received by the Company, the installation shall remain the sole property of the Company, and the hirer shall not be deemed to have bought or agreed to buy the same.

SECTION VII.

THE FREE SUPPLY OF INCANDESCENT LAMPS.

The title of this section, like the term "free-wiring," is a misnomer. But, like many another trade term, it serves the purpose of its adoption better than a more lengthy, if more correct, appellation. It is short, and conveys at once the idea that lamps are, in common parlance, "given away," subject only to certain restrictions and conditions. Strictly speaking, the lamps are given away for the purpose of renewals only, the innovation having been introduced by the author in 1896, and adopted by the Bradford Corporation in the same year. Other towns have since followed on the same or similar lines, and the experience of some is given further on in this section.

In 1896, as far as it has been possible to ascertain, no such practice as the free renewal of lamps had been adopted in any electricity supply undertaking whatever, either on the Continent or in the United Kingdom. But there are very many instances in these countries of supply companies and municipal electric undertakings having undertaken the *sale* of incandescent lamps. The difference between selling lamps and giving them away is an apparently simple matter. When considered in the light of an ordinary commercial transaction it does not, of course, appear to be either a sound or feasible project. But there are many matters in connection with municipal undertakings, and especially the supply of electricity, to which the simple laws of supply and demand do not altogether or always apply, and which, therefore, cannot be dealt with from any one point of view, without taking into consideration the effects and bearings in other directions.

Taking a comprehensive view of the matter, it can be easily shown that a free distribution of lamps to consumers is not only a more satisfactory method on both sides, and more consistent with the position which the undertaking occupies in relation to the public, but that it is also commercially desirable.

In order that it may clearly appear wherein lies the advantage of the one method over the other, and in order also that a lucid statement of the case may be set forth, it is proposed to consider, first, the reasons why the supply of lamps should be in the hands of the Corporation, apart from the question of free distribution; second, the disadvantages arising from the *sale* of lamps; and third, the basis of supply and the financial aspect of providing lamps without charge.

1. *Reasons why the Supply of Incandescent Lamps should be in the hands of the Corporation.*—Before proceeding to enumerate the several reasons why it is desirable for the producers of the current to furnish the necessary lamps, it may be as well to call attention to the fact that in November 1893, the patent owned by the Edison & Swan United Electric Light Company expired. This patent had given them the monopoly of the manufacture of incandescent lamps throughout the country, and in addition to this it was an infringement of the patent for any incandescent lamps of foreign manufacture to be brought into the country. The disadvantage of this to the community was, of course, that the prices of lamps remained very high, not falling below 3s. 9d. each at the very least, and consequently the purchase and subsequent renewal of lamps became very expensive things. But there was distinctly one advantage which the public derived, even in the reign of monopoly. There was only one class of lamps to be had, which the manufacturing company had brought to a high state of perfection and quality. In those days it was not an unusual thing to find the life of a lamp varying from 3,000 to 5,000 hours, and in some instances even longer. Generally speaking, these lamps were undoubtedly expensive in first cost, but the very high standard of excellence attained, together with the careful tests and inspections to which every lamp was submitted

before leaving the factory, rendered renewals much less frequent than is found to be necessary in the case of many inferior lamps which now flood the market. With the expiry of the Edison & Swan United Electric Light Company's patent came the influx of all sorts and conditions of lamps from abroad, as well as a largely augmented supply of home produce from new manufacturers. With regard to a considerable number of these, it may be said that the object was solely to cut down prices and secure an immediate sale. The price of lamps then dropped from 3s. 9d. to prices varying from 2s. to 10d. apiece, the lower-price lamps being invariably of an inferior quality, and frequently little better than rubbish.

These are the circumstances which constitute an important reason why the supply authorities should protect the interests of their consumers by themselves undertaking the supply of lamps, and so guaranteeing, as far as possible, that they get an article which in all respects shall be a fair equivalent in value for the price paid.

With the view of showing how possible and probable it is that the consumer, in purchasing a cheap lamp, will get a very inferior one, it will be well to point out a few of the defects and faults which may exist:—

(a) Low Efficiency.—That is to say, the lamp takes more current per candle-power than that known to be the standard attainable. The practical consequence is that, the consumption being greater, the quarterly bill is increased in proportion.

(b) Too High Efficiency.—The lamp takes much less current than that which is known to be consistent with good results. The indications are not long in developing, and are proved by a short life, rarely extending beyond 100 hours—more often being below that number—and by the immediate blackening of the inside of the globe, thus diminishing the effective light and causing great dissatisfaction. So-called high-efficiency lamps, moreover, do not retain their high efficiency for many hours; the watts per candle-power rapidly increase as the lamp burns, and thus no real saving in consumption is effected.

(c) Defective Filaments and Short Life.—However perfect a lamp may be in other respects, a defective filament, which can only be detected by a careful test and an experienced eye, will soon be burnt out, and thus give the lamp a short life. Now a short-life lamp is a very expensive matter to the consumer, as it means a frequent fresh outlay in lamp renewals. One of the indications of a defective filament consists of a small speck of greater incandescence than the rest of the filament, and at that point it breaks.

(d) Unsuitable Voltage.—Unscrupulous agents will frequently sell lamps which have been designed and calibrated for a different pressure to that adopted as the standard in the town. Hence we find some consumers using 110 volt lamps on a 115 volt circuit, and 220 volt lamps on a 230 volt circuit. When first connected such lamps yield a very brilliant light, a nominal 16 candle-power lamp giving, perhaps, 18 or 20 candle-power. This, however, as in the instance *(b)*, only continues for a very short time, and then the lamps either give out or burn dull, the nominal 16 candle-power soon falling from its unnatural 20 candle-power to as low as 8 or 10 candle-power. Other defects mentioned in *(b)* also apply.

(e) Unreliable Candle-Power.—Many manufacturers do not submit every lamp they turn out to a photometric test. Pressure of business and orders in arrear are frequently the excuses. When we consider that some firms make from 10,000 to 20,000 lamps per week, such an omission is easily accounted for. Yet every lamp is marked or labelled with its presumed candle-power, 8, 16, 32, &c., as the case may be. In taking a number of lamps, however, of supposed identical candle-power, of one make, and placing them in a photometer, wide differences are sometimes found. Nominal 16 candle-power lamps will be found, at times, as low as 12 and as high as 18 candle-power. A variation of 1 candle-power is all that should be allowed; anything exceeding this should be rejected. This, in common with other defects already mentioned can, of course, only be discovered by submitting the article to the test of special apparatus.

(f) Defective Terminals and setting, which cause short-circuiting in the collar, breaking the lamp and damaging the lamp-holder.

(g) Bad Glass.—If lamps are made with bad or inferior glass, it will, on becoming heated, gradually allow absorption of the air, causing short-life by consumption of the filament and blackening of the globe.

(h) General Irregularities, such as convoluted and single-loop filaments, long globes, short globes, and other irregularities due to purchasing lamps from a variety of different makers.

In addition to the foregoing detailed list of faults, many of which may be found to exist together, even in a single lamp, there are other serious drawbacks to which the ordinary purchaser and retail vendor are subject, and for which there is little or no remedy. Unless the consumer has a very large number of lights, and can purchase his lamps in considerable quantities from a reliable manufacturer, he is thrown upon the agents in the town, the majority of whom do not carry their own test of lamps beyond a casual inspection, and who are very loth, of course, to admit the possibility of any defects in the lamps they supply. Such agents, moreover, have not the apparatus necessary to test each lamp for efficiency, candle-power, and probable life, nor could they afford the time and labour even if they purchased the appropriate instruments. The consumer, therefore, has no redress however defective may be the lamps sold to him ; he is without a manufacturer's warranty, and is quite unable to support a case through lack of technical knowledge, and want of testing apparatus. He cannot come upon the manufacturer for free renewals of defective lamps, even if he purchases considerable quantities at a time, for the manufacturer who admitted such a liability would himself be liable to be imposed upon. In the case, however, of corporation orders the matter is entirely different. The manufacturers know that their lamps are carefully handled, stored, and scientifically tested, and, in the majority of cases, including the best makers, they will give a corporation a guarantee of efficiency, candle-power and life, and are glad, rather than otherwise, to have legitimately bad lamps thrown out of a consignment and to substitute good ones in their stead.

All things considered, it is advisable, therefore, that the producers of the current—in other words, the corporation—should furnish the necessary lamps. First, it is, as already shown, distinctly in the interests of the consumer. Secondly, it is in the interests of the corporation, who suffer in reputation when lamps do not give sufficient light, and who are generally but ignorantly blamed as the cause of every mishap and defect that occurs.

2. *The Disadvantages arising from the Sale of Lamps by the Corporation.*—If any corporation, acting as a pure and simple business department, were to undertake the sale of incandescent lamps, they would immediately come into direct business competition with agents and electrical firms in the town. The corporation would necessarily buy in much larger quantities at a time than any single firm; they would obtain the lamps at a cheaper rate and sell at a lower rate of profit, with the inevitable result that practically the whole business in the particular class or classes of lamps sold would undoubtedly accrue to the corporation. But the corporation, by selling only reliable lamps of good manufacture, would probably not interfere with or appreciably affect the continued sale of lower-price lamps in the town, and the consumer would still have the option of choosing the cheaper makes, and would, no doubt, frequently be tempted to try them. There would also be the possibility and the probability of agents selling lamps at a lower price than that charged by the corporation, representing them nevertheless to be of a similar quality and similar manufacture. Of course it would be the object of the corporation to provide only those lamps which could be implicitly recommended, and these would not by any means be the lowest price in the market. Surrounded by all these difficulties and antagonisms, the corporation would most likely fall very short of accomplishing even their primary object—namely, that of ensuring that every consumer was provided with the best lamp that could be obtained. We are, therefore, led to the conclusion that the scheme referred to in this section, viz., that of a free supply of lamps to the consumer—is, for a corporation, the most satisfactory solution of

the matter. Assuming that the object of the corporation generally is to give to the consumer the greatest possible satisfaction with the supply of electricity, it seems beyond question that this can only be accomplished by presenting him from time to time, under proper restrictions and safeguards, with the most efficient lamp for his use. The consumer ought to find that his stock of spare lamps for renewals was never larger at one time than another, and that it should be from quarter to quarter in exact proportion to his consumption of electricity. How this can be arranged, and the advantage of it, will be explained under the next heading.

Before proceeding, however, there is still another aspect of the sale of lamps which must be considered. By taking up the sale of lamps, the corporation would be starting an entirely new and distinct department from the electricity works, which would rapidly grow into an important concern. They would be selling lamps day by day, not only to their own consumers, but to any person who might apply, and this would entail a special staff of competent persons, who would be exclusively engaged on testing and examining lamps. Providing free of charge a certain number of lamps for a definite consumption of electricity would, however, be a different thing altogether. The distribution of the lamps in this case would only occupy a few days at the end of every six months, and the necessary tests could be made without difficulty by the present staff.

We now proceed to deal with some figures showing the calculated effect of the proposed free supply upon the undertaking.

3. *The Basis of Supply and Financial Aspect of providing Lamps Free of Charge.*—Every incandescent lamp, if properly made, consumes a definite amount of electricity, and this is represented in the statement that one candle-power requires $3\frac{1}{2}$ watts. Hence a 16 candle-power lamp requires 56 watts, and the Board of Trade unit being 1,000 watts for one hour or its equivalent, it follows that a 16 candle-power lamp must be in use for $17\frac{6}{7}$ hours before a unit of electricity is consumed. If, therefore, we know how many units have been used by any given

consumer, we can ascertain at once how many hours a 16 candle-power lamp would be burning, in order to consume that number of units. This, of course, would be equivalent to adding up the total number of hours of each single lamp which had been in use. Now the number of hours which represents the average life of a lamp is 1,000. A good lamp will frequently last 2,000 or 3,000 hours before it actually breaks down, but it is not advisable to use them longer than 1,000 hours, as after that time they rapidly get coated on the inside of the glass with a sooty deposit, and the candle-power rapidly diminishes. The basis of supply—or, in other words, the correct time for the renewal of a lamp—is, therefore, once in every 1,000 hours of consumption. Now a 16 candle-power lamp, burning for 1,000 hours, consumes exactly 56 units, which, at 5d. per unit, amounts to £1 3s. 4d. The cost of each lamp in buying large quantities is at present about 1s. each, and adding 2d. for testing, warehousing, &c., the gross price is 1s. 2d. per lamp. On the foregoing basis, the consumer would be entitled to one 16 candle-power lamp for a consumption of every 56 units, which represents a reduction of 1s. 2d. on an income of £1 3s. 4d. This is equivalent to a reduction in the price per unit of ·25 of a penny, or 5 per cent. The practical effect of this reduction may be shown as applied to the accounts of the Bradford Corporation for 1897.

Total number of Units sold		735,743
Less Motors	117,176	
Less Arc Lamps	124,201	
Less Public Lighting	16,468	
	257,845	257,845
Total Units for Incandescent Lamps		477,898

UNITS. UNITS.

477,898 ÷ 56 = 8,534 lamps required.

8,534 lamps at 1s. 2d. each = £497 16s. 4d.

Our net profit in 1897 was £1,879 14s. 9d., but taking into account

the above expenditure it would, of course, have been reduced to £1,381 18s. 5d.

It will be seen from the above calculation that this renewal of lamps affects only the current used for incandescent lighting. Moreover, the basis of supply entirely obviates any enquiries or investigations into the number or candle-power of the consumer's lamps or how he uses them. He would simply be entitled to one 16 candle-power lamp for every 56 units consumed, the only stipulation being that no current for motive power or arc lamps should be taken from the same circuit. He would, at the end of every half-year, receive an intimation from the department that having consumed so many units, say 560 for example, he was therefore entitled to ten 16 candle-power lamps free of charge (or their equivalent in any other candle-power, such as five 32 candle-power), and he should be required to accept delivery only on application to the corporation stores. The lamps having been previously carefully tested and examined, the corporation would admit no liability after they had once left the stores.

The consumer would, of course, be required to give a receipt for the number of lamps taken away, and it would be left to him to ascertain what lamps were becoming too black, what lamps required renewing, and to decide according to his own discretion where they should be placed.

We have now somewhat exhaustively dealt with the question of the free supply of incandescent lamps to consumers, and have endeavoured to show that the interests of the electricity department, its progress and its popularity, will be best served by giving a perfectly satisfactory light to consumers. This, of course, can only be accomplished through the medium of good lamps, by safe-guarding the consumer as far as possible from fraud and imposition, and by relieving him from unnecessary expense.

Objections to the Scheme.—Some objections to such a scheme as that just described will be certain to occur to the reader, and they have been considered as serious obstacles to its adoption by some municipal

engineers and councillors. It will, therefore, be of advantage to set out, and frankly consider them in the light of experience, which, of course, was not possible when the scheme was first adopted by the Bradford Corporation. These objections may be stated to be as follow, viz. :—

1. That the free renewal of lamps by a municipality is unfair to local tradesmen.

2. That the scheme has a tendency to favour one lamp manufacturer more than another.

3. That it is unfair to other consumers using arc lamps and motors.

4. That the "handling" and storage of free lamps is an expensive item.

5. That consumers do not replace blackened lamps.

6. That it is not consistent with certain methods of charging for electrical energy.

7. That a sliding scale of discounts on the annual bill serves the same purpose.

8. That the consumer would, perhaps, *sell* his free lamps.

This is a sufficiently lengthy list to necessitate careful consideration, but most of them can be readily overcome or explained away. Some are real and of some importance; others are merely imaginative. We will deal with them in the order given above.

With regard to the *first* and *second* objections, it must be admitted that the tendency of free lamp renewals is, to favour one manufacturer more than another, and to take the sale of lamps, by local wiring firms, very much out of their hands. These, however, should be looked upon rather as advantages than as drawbacks. As a matter of fact, the free renewal of lamps seeks, as one of its distinct objects, to prevent the sale of inferior lamps by small wiring firms, and also implies purchasing from that manufacturer who can supply a lamp with the highest efficiency and longest life at the most economical, though by no means the lowest, price. The object, of course, is to guarantee to the consumer what he has no possible means of finding out and securing for himself. At the time of the change over of pressure, at Bradford, from 115 to 230 volts,

many of the "stock" lamps taken from consumers' premises, to be replaced by 230 volt lamps, were tested for candle-power and efficiency, and, in the majority of cases, were found to be taking from 4 to 6 watts per candle. No maker's name appeared on the bulbs. They were, of course, so-called *cheap* lamps, which probably accounted for very considerable increases in the consumption of electricity. From the manufacturer's point of view, we may take the publicly-expressed opinion of a well-known and large lamp manufacturer, who says :—

"The consumer, as a general rule, is not an electrical expert, and cannot apply the tests to his lamps that can be applied by the station engineer; his interests would, therefore, be much better looked after in regard to the cost and quality of his light, than he could possibly look after them himself. And, if the chief customers of the manufacturer are large supply stations who will require that the lamps supplied fulfil a prescribed specification, the quality supplied to the public will inevitably be raised. It may appear, at first sight, that the interests of the supply station and of the consumer are not identical, inasmuch as the more current the consumer uses in his lamps, the more profit is made by the station. But so short-sighted a policy as this is not likely to be adopted by any intelligent business men, in presence of the gas competition, for if the consumers' bills increase in amount, the number of customers for electric light will certainly diminish. It is the interest of supply stations to cheapen, as much as possible, the cost of electric light, so as to extend its use. Of course, lamp manufacturers will not complain of a system that so reduces the risks and trouble of their business."

The *third* objection is a more real one, as it will be seen in a previous part of this Section that the reduction off the account, represented by the gift of the lamp, varies from 3 per cent. to $6\frac{1}{2}$ per cent., according to the price of the lamp. It is, of course, impossible, or at least impracticable, to give equivalents such as carbons or oil to arc lamp and motor users. It has, however, been suggested, that an additional discount should be made to these consumers, and that appears to be a reasonable solution of the difficulty.

The *fourth* objection is not so serious as appears at first sight. It is true that some 8,896 lamps per 1,000 kilowatts of maximum demand have to be handled per annum, but this can readily be done by one man. With a combination photometric and efficiency testing apparatus, an enormous quantity of lamps can be dealt with readily, quickly, and yet satisfactorily, at the cost of but a fraction of a penny per lamp. "Life" tests should be made with half-a-dozen lamps promiscuously taken from each consignment. The delivery to the consumer recurs only once every three months or six months, and, if carried out on the plan adopted by the author and referred to later on, no trouble will be experienced. With regard to storage, a simple practical trial will show how many lamps can be stored in a given area.

In reply to the *fifth* objection, it can only be stated that in those towns in which the scheme has been in operation an appreciable time, experience goes to the contrary.

The *sixth* objection refers to the idea suggested by some municipal electrical engineers that the rate of rebate, if taken on the actual intrinsic value of the "free" lamp, is unequal on accounts for similar consumption but with varying maximum demands, where the maximum demand or time-switch methods of charging are in operation. An illustration of this occurs at Worcester, where the scheme and the demand tariff are working in conjunction, from which the following example is taken:—

A consumer with thirty-six 33·3-watt lamps, using all lamps simultaneously, will have a demand of 12 ampères, and will therefore have to burn $12 \times 36{\cdot}5 = 438$ units in the year at 6d., before he gets a rebate. This consumer will pay—

438 Units at 6d. = £10 19s. 0d.

for electricity, and hence is entitled to $\frac{438}{50}$ = eight lamps at, say 1s. each, equal to a discount of 8s. on £10 19s., or about 3·6 per cent. On the other hand, the consumer with a maximum demand of four ampères and a three-hours average use, and burning the same number of units, would pay—

	146	Units at 6d.	= £3	13s. 0d.
	292	,, ,, $2\frac{1}{2}$d.	= £3	0s. 10d.
TOTAL ...	438	,, ,, $3\frac{3}{4}$d.	= £6	13s. 10d.

This would entitle him to a similar number of lamps, and hence the monetary value of the lamps, viz., 8s., would in this case be equivalent to a discount of about 6 per cent.

At Worcester, however, it must be stated that this is considered in its really true and correct aspect, viz., that the scheme tends to still further lower the cost of the electric light to the longest, and therefore the best-paying consumer, without in any way affecting the *rate of profit** on the account as far as the corporation is concerned. As a matter of fact, the one scheme does not in any way affect the *rationale* or basis of operation of the other.

The *seventh* objection may be dismissed, as having been already sufficiently proved fallacious in the earlier portions of the Section.

The *last* objection is one which must be accepted as a possible, though not probable, contingency. Where, however, every consumer gets his *pro rata* supply of free lamps, there will be practically little or no surplusage to sell.

It will now be as well to consider the experiences of certain places where such schemes have been adopted, together with the basis upon which each is worked and peculiarities in connection with them.

In America, for instance, the practice has been adopted in even a more liberal spirit than anything which has been suggested in this country. In a letter which was recently communicated to the technical press,† the writer says :—

"You may be interested in the practice of our Edison Companies. Lamps are furnished absolutely free. When a customer is connected, he is given one lamp of any candle-power wished for each socket, and a moderate supply of lamps to take the place of any burned out or broken. If at any time he increases his installation, he

* See Section III., page 33.

† *Lightning*, page 905, Vol. XII., No. 314.

is given new lamps in proportion to the number of new sockets wired. Whenever a lamp filament breaks or the lamp falls below candle-power, the customer can obtain a new one on returning the old bulb to the supply office, but no allowance is made for a broken bulb. Formerly, the rule as to candle-power was that if a 16 candle-power lamp fell to 13 candle-power, a new one could be obtained for it. The present tendency is to give the customer a new lamp, in return for the old one, whenever the customer asks for it. I have seen lamps returned that tested over 16 candle-power, the supply company making no objection, but merely turning the lamp back into stock. This privilege is not in general subject to abuse ; in fact, even with this privilege, the customers are apt to burn the lamps too long for the best results, and many companies utilize the spare time of some of their help in inspecting lamps on the customers' premises, and replacing any that are not up to candle-power. Of course, if a customer wishes to burn his lights after they are below candle-power, he is allowed to do so ; but the companies feel that the better light and better satisfaction of the customers more than pay for the cost of lamp renewals.

"It seems to me that the general principle of free lamps is right. If every customer asked for a new lamp whenever an old one fell to 15·9 candle-power, it might be impracticable ; but the actual working is that, even with free lamps, the customers use them too long rather than not long enough, and the company is the best judge of the economical smashing point of the lamp rather than the individual customer. Of course, besides using the lamps to the best advantage, the customer also gets the advantage of buying lamps in large quantities, so that in the end it is much cheaper. The American method gets over several of the arguments advanced in the issue of *Lightning* I have at hand. The company will, ninety-nine times out of a hundred, prefer to smash lamps at an earlier point in their life than will the customer, who hates to spend money for a new lamp while the old one will burn ; therefore free lamps mean that a much greater total quantity of lamps will be used, and so it is to the advantage of the lamp

companies.

"Of course, the question of giving an equivalent to the man who uses his electricity for arc lamps, or motors, or storage batteries, is something to be considered. Here in America, the almost universal custom is to have the central station trim the arc lamps and supply carbons, and this is included in the price, different rates being made according to the use made of the current. In the case of small users this is, of course, an objection; but very few small users want to use the current for more than one purpose, and for large customers the expense of the extra meters and bills is a very slight percentage."

At *Worcester*, to which reference has already been made, the electrical engineer communicated with the principal lamp-makers, asking for curves, &c., of the most constant candle-power lamps that they could make, and as a result found it was possible to obtain a lamp in which the early rise in candle-power did not exceed 10 per cent. of the nominal, nor did it fall below the initial candle-power in less than 275 hours; while at the end of 800 hours the decrease did not exceed 12·5 per cent. below the initial candle-power. The basis upon which renewals are made in Worcester, is the assumption of 800 hours as the life of the lamp. In that time a 16 candle-power lamp will consume 50 units of electricity, with an average wattage of 62·5. Other conditions are similar to those in operation at Bradford, as described further on in the Section.

Mr. F. J. Warden-Stevens has suggested a somewhat original basis for the free supply of lamps, which does not take as an assumption any particular number of hours as the "life" of the lamp. He suggests that each consumer should pay for one lamp per annum per lamp-holder installed, all lamps necessary over and above that number to be supplied free. The conditions of the free supply are—First, that the lamp in use blackens excessively or breaks; and, secondly, that the candle-power is in excess of, or less than, a certain percentage of variation from the normal. If there is any doubt about a lamp it should be tested, but a charge of sixpence is made if a lamp is tested by request and found to

be up to the stated standard. It is also proposed that the arrangement should be quite optional to consumers, but that, if adopted, they must agree to submit to an inspection of their lamps at any reasonable time. All lamps bear a distinctive mark, and old ones must be returned. If at any time the proper number of marked lamps are not found, the balance must be paid for in cash.

Such are the conditions imposed, but details as to the actual working of this system are not yet obtainable.

At *Bradford*, the basis and conditions of the supply of free lamps are as follows:—

BASIS.

16	candle-power lamp,	burning	1000 hours,	consumes		60	Units.
25	,,	,,	,,	,,	,,	94	,,
32	,,	,,	,,	,,	,,	120	,,
50	,,	,,	,,	,,	,,	188	,,
100	,,	,,	,,	,,	,,	376	,,
200	,,	,,	,,	,,	,,	752	,,
300	,,	,,	,,	,,	,,	1,128	,,

and so on.

Conditions of Supply on Foregoing Basis.—1. Every consumer of electricity from the corporation mains will be entitled to one 8 or 16 candle-power incandescent lamp, supplied free of charge by the Bradford Corporation, for every 60 units of electricity consumed by the use of incandescent lamps only. If other and higher candle-power lamps are desired instead of 16 candle-power, the number of lamps to which the consumer is entitled will be in the inverse ratio to such candle-power. Thus:—

60	Units	entitles to	1—8 or 16 c.p. lamp.
120	,,	,,	2—8 or 16 c.p., or 1—32 c.p.
240	,,	,,	4—8 or 16 c.p., or 2—32 c.p.
480	,,	,,	8—8 or 16 c.p., or 4—32 c.p., or 2—50 c.p.

(The balance of units consumed in excess, viz., 105 in this last instance, being held over until the following six month's supply, or made up by lamps of a lesser candle-power as may be desired by the consumer.)

2. The consumer may choose the class of lamp terminal he prefers *i.e.*, either screw or brass collar up to 50 candle-power, and may also have the lamps entirely frosted, half-frosted, or plain ; but after the lamps have once been delivered to him no exchange will be made under any circumstances.

3. The lamps will be delivered to the consumer only at the Corporation Stores, Electricity Works, Bolton Road, Bradford, where he must send for them and provide the necessary convenvience for removal.

4. At the time of delivery of the lamps the consumer must sign an official receipt, which will be provided at the stores.

5. Upon making application for lamps, the consumer must produce his *receipted account* for electricity from the Borough Collector's Office, and if the account is not paid on or before the last day of the second month from the expiration of the half-year in which the electricity is consumed, the consumer will forfeit his right to any lamps he would have been entitled to under that account.

6. No lamps will be given under any circumstances whatever, unless the receipted account is produced.

7. The lamps will only be obtainable at the end of every six months ending June and December respectively, notwithstanding any arrangement for the payment of accounts quarterly.

8. After the lamps have been handed to the consumer or his representative, the corporation will not recognise any breakage, defects, or accidents to the lamps.

9. Lamps must be removed, carried and handled with the greatest possible care and delicacy, in order to prevent straining or fracturing the filament.

10. All lamps will be marked with their respective voltage, candle-power, and maker's name.

11. Each lamp will have been carefully tested and examined before delivery to the consumer, with a view of eliminating all defects, and of providing a lamp perfectly satisfactory as regards standard candle-power, probable life, class of filament, mechanical construction and efficiency.

12. In the event of the consumer cancelling his application or giving up the electric light, or leaving the premises for which he has required the supply of electricity, he shall not be entitled to any lamps for his consumption of electricity for the then current half-year, except and unless he removes to other premises adjacent to existing electricity mains, and continues to be a consumer.

13. The lamps supplied may be safely used in any position, *i.e.*, vertically downwards, vertically upwards, horizontally, or at any angle. It must be pointed out, however, that a lamp is likely to last longer when hanging in a perfectly vertical position than in any other position.

(Each consumer is provided with a card of these conditions of supply).

It will be seen from the foregoing conditions, that an endeavour has been made to eliminate as far as possible any chance of applying for, or dealing with, the lamps in a fraudulent manner by the consumer. As a matter of fact, after two years' experience, it has been found that it is practically impossible to obtain lamps fraudulently, and, further, that the conditions entail the very least amount of extra work upon the electricity department. During each six months the storekeeper or his assistant tests a certain number of lamps daily, which are then put aside into stock, for the supply on the subsequent accounts. The tests consist of burning each lamp for a short time, first at full voltage and, secondly, at a reduced voltage, the latter being to ascertain any irregularities of incandescence in the filament itself. The candle-power and wattage are taken simultaneously in a combination testing arrangement, which shows within a small percentage any deviation from the normal. With regard to the life of the lamps, a dozen are selected indiscriminately from each consignment and tested.

Handling.—The actual handling of the lamps is also made a very simple matter. The consumer, personally or by deputy, presents his *receipted* account to the storekeeper at the works. The account is divided as follows :—

	£ s. d.
Units for Incandescent Lighting at 4½d. ...	
Units for Arc Lighting at 4½d....	
Units for Motive Power at 2½d.	
TOTAL ...	

Each account when sent has a label attached, which reads thus :—

PLEASE NOTE.—Upon presenting this account with the official receipt attached, at the Stores, Bradford Corporation Electricity Works, Bolton Road, you will receive a number of Incandescent Lamps, in proportion to the number of units which have been consumed for incandescent electric lighting, provided the account is paid before 189

By simply dividing the number of units corresponding to the candle-power of lamp the consumer requires (60 units for one 16 candle-power lamp, &c.) into the number of units consumed for incandescent lighting, the storekeeper arrives at the number of lamps to which the consumer is entitled, and for which he signs in a book kept for the purpose (Fig. 15).

FREE SUPPLY OF INCANDESCENT LAMPS BOOK.

No.	Date	Name	Address	Number of Units sold	Number of 16 c.p. Lamps entitled to	Number and Candle-power of Lamps received	By whom received	Date received	Remarks

FIG. 15.

The consumer is entirely responsible for the lamps after they have been handed to him, and can do with them what he pleases. No old lamps are asked for in exchange, and he replaces worn-out or blackened lamps in his installation at his own discretion.

Results of the Working of the System.—In order to carry the conditions into effect, it was necessary, in those cases where both arcs

and incandescents were used, to place all arc lamps on separate circuits. This, of course, also involved a separate meter, and the rental for it. But it is important to observe that there has been no case in which the value of the free-lamp renewals did not exceed the extra meter rental. Two very important results are the outcome of this necessity to use two separate meters on a combined arc and incandescent circuit, viz.:—

1. The avoidance of many complaints as to the registration of meters.

2. The better regulation of the type of meter to the nature of the circuit.

In respect of the *first* of these it had been customary, previous to the adoption of the free-lamp system, either to remove for testing, or to test on the premises, the meter of which the accuracy was questioned by the consumer. If, after testing, the meter was found and stated to be correct, that statement, it is almost needless to remark, would, in most cases, be received with marked incredulity. It is, indeed, a result not to be unexpected when it is remembered that consumers, as a rule, know nothing whatever about the rate of consumption of electricity for any particular apparatus. In connection with this scheme of free-lamps, however, each consumer has a card upon which the basis of lamp renewals (and hence the consumption of energy per lamp) is clearly set forth. When, therefore, a complaint is made, the consumer is referred to the information on his free-lamp card, and is asked to watch the registration of his meter under definite conditions. He is, in short, practically to test for himself. Taking the exact registration of his meter, and then switching on, say, five, ten, or twenty lights, as the case may be, he keeps them alight for one hour or two hours exactly, and, at the end of that time, again reads the meter. He is shown that the registration should be, say, one, two, or more units exactly. The experiment naturally proves more satisfactory to him, than any private test which the corporation itself might make. Moreover, by this simple expedient, much time and trouble is saved to the corporation meter department.

The *second* result is, if anything, the more important of the two, the corporation, however, reaping the advantage more than the consumer. By placing a separate meter in all arc lamp circuits, it is possible to arrange for a particular type of meter most suitable for the work which it has to perform, viz., registering with the greatest accuracy at all variations of current in the circuit. We are enabled to place one type of meter on arc lamp circuits, another type on incandescent lamp circuits, and a third on motor and heating circuits. There are, at present, many types of meters in the market; motor meters of the current and watt types, pendulum meters, and an electrolytic meter. It is well-known that each of these has certain distinctive characteristics. Some remain accurate at full capacity, but vary considerably at light loads, registering, in some cases, only 50 per cent. of the energy passed; others become permanently high in registration if any current in excess of their capacity is passed through them, such, for instance, as occurs with a short circuit in an arc lamp or switch. It has, therefore, been found advisable to use four different types of meters at Bradford, each of which is allocated to its own peculiar purpose. On all motor circuits a well-known type of watt-meter is used, as it is found more responsive to variations in the load than current or pendulum meters. A watt-meter is, moreover, unaffected by temporary excess currents, and yet is sufficiently sensitive to register accurately the very light load when the motor is doing no work.

On arc lamp circuits, the conditions are such that it is rarely the case that less than 5 ampères are used. On the other hand, the meter is generally working at its full capacity, and occasionally, when the arc lamps are switched on, the current rises probably to 100 per cent. increase for a short period, until the lamps have finally settled down to their normal working current. On these circuits, therefore, a meter is employed which is accurate from 5 ampères to its full capacity, and which is unaffected by temporary excess current. On incandescent lamp circuits, two different types of meter are employed, viz., a permanent magnet motor type current meter on all circuits of more than thirty 16 candle-

power lamps, or over 10 ampères maximum demand; an electrolytic meter for all circuits below 10 ampères maximum demand. In the first case, it is well known that certain types of permanent magnet meters are liable to become sluggish or inaccurate in registration at loads below their normal capacity, after being on circuit a short time. If, on the other hand, they are subjected to loads beyond their capacity, the permanent magnetism is increased, and their registration remains high until recalibrated. For instance, at Bradford, one and the same meter was used on a combined arc and incandescent lamp circuit in which there were, say, twenty 16 candle-power incandescent lamps and four 10 ampère arc lamps. The capacity of the meter on such a circuit would have to be 25 ampères, and during the day-time, or at ordinary lighting-time, only a proportion of the incandescent lights were used. When the meters were tested at such light loads, the registration was found to be very imperfect, entailing great disadvantage and loss to the corporation. When, however, the circuits were divided, a meter of suitable type and capacity was placed in the incandescent lamp circuit, with much better results.

Looking upon this arrangement of meters generally, the advantages are found to be :—

1. Accuracy of registration at light loads, representing greatly increased sale of units per annum.

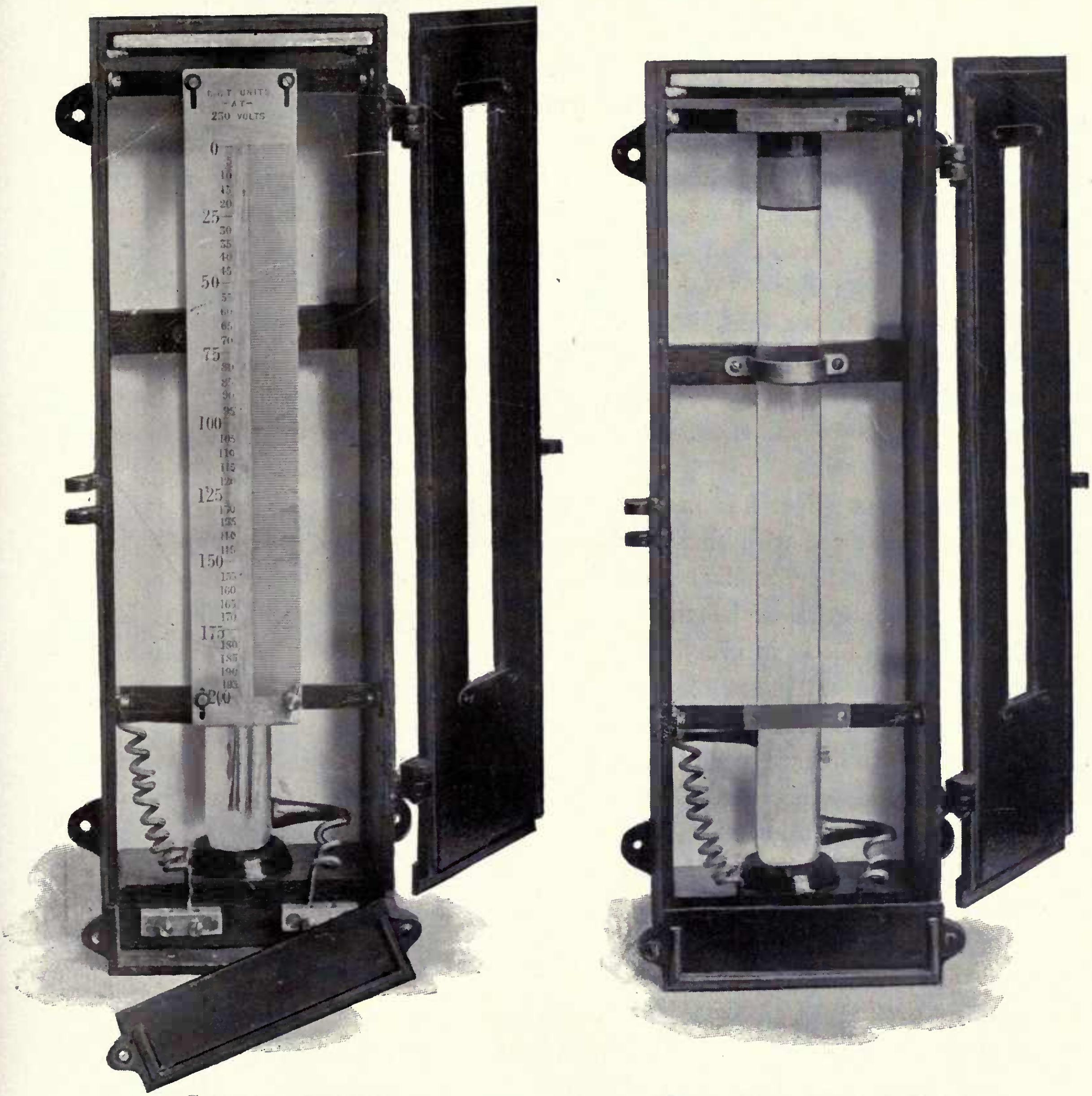
2. Greater reliability in meter-reading, and in the working out of accounts.

3. Greater facility in forecasting probable requirements of meters, and the particular type wanted.

4. Easier and more expeditious meter-testing at the electric light works.

The electrolytic meter referred to above, and which is used on all incandescent circuits below 10 ampères maximum demand, is illustrated in Fig. 16.

It has been adopted for this purpose by reason of its extreme and unvarying accuracy at all loads, its cheapness in initial cost, and the absence of any mechanism to get out of order.



Complete Meter. Meter with Scale Removed.

Fig. 16.

A paper, fully descriptive of this meter, was read by the author before the Institution of Electrical Engineers, on 12th May 1898, and is published in the Proceedings, part 136, vol. xxvii.

To revert to other results of the working of the system, we find a *third* advantage in the prompt payment of accounts. The number of accounts outstanding at the end of August 1896—that is, at the end of the first two months after the expiration of the half-yearly meter-readings, and before the free supply of lamps was introduced—were represented by £1,000, on a gross income of £6,000, or $16\frac{2}{3}$ per cent., notwithstanding that a reduction of $2\frac{1}{2}$ per cent. was allowed on all accounts paid before that time. At the end of August, 1898, the corresponding period to 1896, the outstanding accounts were under £700, on a gross income of £9,400, or under $7\frac{1}{2}$ per cent., and most of these outstanding accounts represented electricity used for other purposes than lighting.

A *fourth* effect has been noted in the fact that nearly all new customers stipulate with their wiring contractors that the lamps supplied, in the first instance, shall be of the same make and design as those adopted and purchased by the corporation. Hence the wiring firms in the city find that it is practically useless to purchase cheap and inferior lamps, and thus an influx of inefficient lamps of the useless German type is indirectly, but almost entirely, prevented.

A *fifth* advantage has arisen from the circumstance that, having lamps in hand, consumers have at once utilized them to replace lights which had been allowed to fall into disuse. This oversight in not replacing lamps which are burnt out, is characteristic of a considerable proportion of consumers, as may be seen in any town, and the fact is probably accounted for by the expense incurred in keeping a stock of lamps on hand.

A *sixth* advantage consists in each consumer being able to enjoy the same quality of light as his neighbour. It was no uncommon thing in time past to see two different installations side by side, one of which, having comparately new lamps, rejoiced in a correspondingly good light,

whilst the other, whose lamps had seen better days, glimmered with light that could hardly be dignified with the title. This was a frequent cause of complaint, and, needless to say, the true explanation was not always accepted by the consumer as gospel. All these advantages—collateral to the main intention, which has been amply fulfilled, of giving a thoroughly reliable lamp to the consumer—are not to be lightly set aside. They have, as already stated, given great satisfaction to consumers on the one hand, and to the corporation on the other; and it has proved, in this short period of time, a movement of wisdom and good policy on the part of the electricity committee.

High-Voltage Lamps.—With an influx of high-voltage lamps, owing to the daily increasing adoption of a minimum supply pressure of 200 volts by corporations and electricity supply companies, there is every reason to fear a repetition of lamp troubles which occurred with the transition from the 50 volt to the 100 volt lamp. High-voltage lamps, as those designed for pressures above 200 volts are now called, are much more difficult to manufacture than 100 volt lamps, the filaments requiring more delicate handling, or more accurate adjustment, according to the particular arrangement adopted. As a matter of fact, the arrangement of the filament or filaments is a most important feature in these lamps, because it affects the "life" and consequent efficiency. High-voltage lamps are now made in candle-powers, from 8 candle-power upwards. The higher candle-powers, such as 100 candle-power and above, do not present quite so much difficulty in manufacture as the smaller sizes. Such lamps have been already made for 100 volts, in which two or more filaments have been connected in parallel in the one globe, and hence the alteration consists chiefly in changing from a parallel to a series connection. Lamps below 100 candle-power, however, may be classified according to the distinctive arrangements of the filaments, and, first of all, they may be divided into two main classes, viz., double-filament and single-filament lamps. These, again, may be sub-divided according to the particular forms of filament adopted in each class respectively. Each of these many and various arrangements has

advantages peculiar to itself, and, in the interest of the purchaser and user, it will be as well to consider briefly the points and conditions where one form would be more suitable than another.

We will, first of all, deal with the double-filament high-voltage lamp, as that was the first form adopted, and still continues to be the

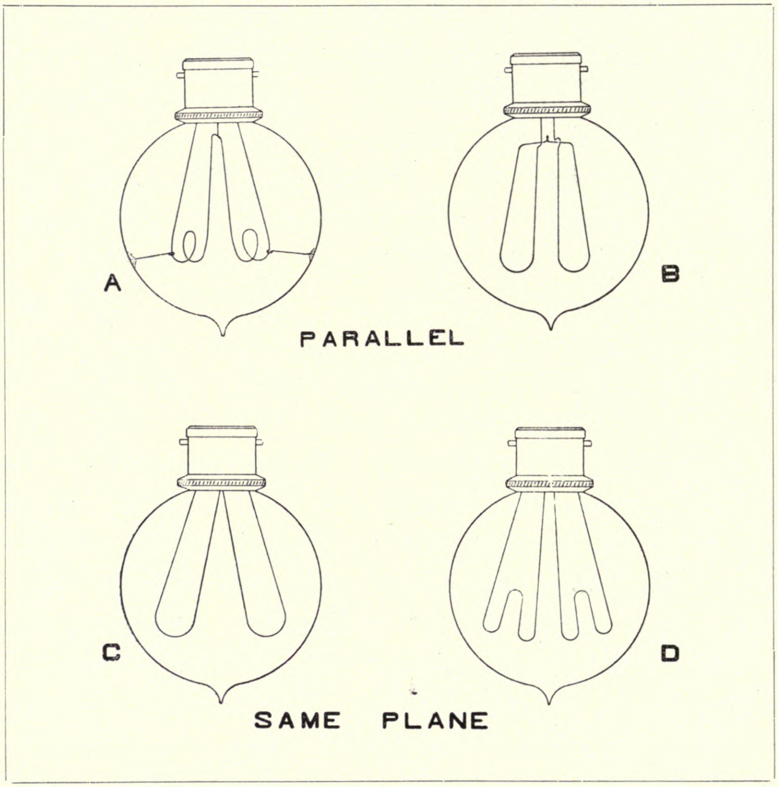


Fig. 17.

more general method of the two. In this type, the filaments are arranged either in the same plane with each other, or are parallel to one another, and these are illustrated diagrammatically in Fig. 17. Incidentally we may remark that the drawings do not represent the actual form of lamp of any particular manufacturer.

It will be readily seen, from the four examples in this figure, that a very much greater space in the globe is occupied by the double filaments than is usually required for 100 volt lamps. The inevitable result of this arrangement is, that the filaments have an increased tendency either to short circuit upon themselves, or to touch the glass. In either case the lamp becomes useless, through the cracking of the glass or the consumption of the filament. This liability is of rather a serious nature, as the lamp may thus become useless at a much reduced "life" from what is considered to be the average for any lamp of given watts per candle-power. If we take 1,000 hours as the average life of a lamp at $3\frac{1}{2}$ watts per candle-power, we shall find that the type marked "A" in the figure will not give satisfaction. The filaments in this lamp are shown shackled to the glass, and there are, at least, two important drawbacks to this method of keeping the filaments apart from each other. They are *(a)*, a liability to air-leakage at the point of junction of the shackle with the glass, through frequent expansion and contraction; *(b)* a cutting of the filament itself by the shackle.

With regard to double-filament lamps, therefore, it is better to choose the lesser of two evils, and rely upon the unshackled and self-supporting filament. In most types these filaments will be found quite satisfactory, if the lamp is used in a perfectly vertical position, the collar being uppermost. It is in positions out of the vertical where trouble is likely to arise. Many electric light fittings, for instance, are so designed that the lamp is used at angles of 45, 50, 60, and 90 degrees with the horizontal, the collars in some being lower and in others being higher than the bulb. There are also cases in which the lamp is required to burn vertically, with the collar on the under side, as, for instance, for footlights in theatres. Where lamps are required for such places as these, it is, of course, a matter of primary importance to see that the type is the most satisfactory that can be obtained for the purpose.

Having considered the conditions of use of double-filament high-voltage lamps, we now come to those with single filaments. This type is, of course, more nearly like those in general use for lamps of 100-115

volts. The filament, however, must either be twice the usual length, or of less sectional area. In either case, the filament is much longer than that required for 100-115 volts, and hence some device in the nature of convolutions or "waves" must be used, in order that the filament shall not occupy too great a space within the globe, the entire lamp being kept as nearly as possible to the already established sizes of those of lower voltage.

In Fig. 18, an illustration is given of two forms of single-filament lamps. A casual glance will readily show that the type marked F

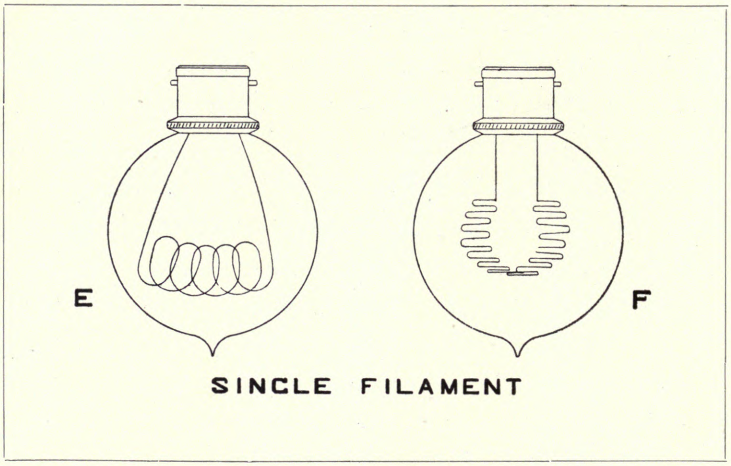


Fig. 18.

occupies less space than that marked E, and consequently it is better adapted for use in any position, without the attendant liability of touching the glass, or of short-circuiting upon itself. This type is made by the Zurich Incandescent Lamp Company, and is a most efficient and satisfactory high-voltage lamp.

Other types of single-filament high-voltage lamps are also upon the market, but they are chiefly characterised by unnecessarily large bulbs, shackled filaments, and other defects, which seriously affect the life of the lamp.

SECTION VIII.

PREPAYMENT METERS.

Amongst the many novel features which have been introduced into the business of the public supply of electricity during the past year or two, the prepayment meter must take a prominent place.

As known by the more colloquial title of "penny-in-the-slot meter," it will be recognised that the prepayment device is but an application of the principles of the coin-freed apparatus, with which the public have now become so familiar, in the form of automatic weighing machines, and similar classes of apparatus. In addition to these, however, the principle has been applied to gas meters with most encouraging results, and hence the adaptation of the electricity meter for prepayment purposes, is but following in the footsteps of a movement which has already been proved, in other directions, a practical and financial success. Up to the present time the prepayment electricity meter is not in very extended use, and it is not possible to speak of its success with the same assurance as in the case of gas meters. It is, however, rapidly becoming more extensively adopted, the chief reason of its hitherto slow progress being the initial cost. Until within a few months ago all meters cost over £3 10s., and the addition of a prepayment attachment brought this figure up to £5 or £6. But there is now an electrolytic meter in the market, which, inclusive of the prepayment attachment, costs under £3. This attachment is described further on, the meter itself having been referred to and illustrated in Section VII.

While there may be many points of difference between the supply of gas and the supply of electricity, by means of prepayment meters, there are also many points of analogy. They are, at any rate, so far

alike that we may reasonably expect for both a similar tide of success. It will be as well to give some statistics showing to how considerable an extent the gas prepayment meters have passed into general use.

There is, at the present time, hardly a gas corporation or company, of any size, in the United Kingdom, which has not some slot-meters in use. They are even used in connection with gas cookers, and an interesting series of articles on this recent development have appeared in one of the journals devoted to gas interests.* Returns from the gas undertakings throughout the country show that about 500 to 600 have introduced the slot-meter. In many cases it is used to a large extent. In London, the Gas Light and Coke Company, has over 90,000 out of a total of 320,000; the South Metropolitan Company, 72,000 out of 162,000; the Commercial Company, 9,000 out of 31,000; and the Tottenham Company, 6,500 out of 13,300. In the provinces, Manchester has 22,000 out of 112,000; Macclesfield, 1,800 out of 4,780; Rotherham, 4,600 out of 8,700; Stafford, 1,200 out of 3,300; and Wath-on-Dearne, 900 out of a total of 1,400. In a great many other instances, the proportion of slot-meters to ordinary meters is about one-third, in some cases it is higher, but in the majority it is lower, probably because of its recent adoption.†

Very slight records at present exist as to the adoption of slot electric meters by corporations or companies. Some are in use in Reading and in Bradford, and they are being tried experimentally elsewhere. Their more complete and extensive adoption, however, is but a matter of time. For there can be no doubt but that the prepayment meter, in its own sphere, will prove equally as useful, acceptable, and necessary, in the case of electricity supply, as it has done in the case of gas supply.

‡*Advantages.*—The adoption of prepayment meters, which may be arranged for either pennies, sixpenny pieces, shillings, or other coins, in

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* *Journal of Gas Lighting, Water Supply, &c.*, November 1898 issues.

† For further details see *The Gas World* Year Book, 1898. Published by J. Allans and Company, 3 Ludgate Circus Buildings, London, E.C.

‡ See also "Penny-in-the-Slot Electricity Supply," *Lightning*, December 17th, 1896.

connection with the supply of electricity by a municipality, is attended with many advantages to both consumer and corporation, and these may be set out as follow:—

1. The advantage in itself of prepayment. Considered simply as a financial arrangement, prepayment is a very appreciable matter to a corporation, as it avoids the necessity of making out and collecting accounts. Bad debts, of course, cannot be, and this, moreover, among a class of consumer with whom the cost of the service, compared with the number of lights used, is usually high. As regards the consumer, it may be claimed that prepayment is also an advantage to him, inasmuch as a quarterly or half-yearly electricity account would be, in most cases where such meters would be adopted, entirely beyond his means or his ability to meet. This is true in a much wider sense than appears at first sight. By the quarterly method of registration and payment, the consumer, as regards the amount of consumption, is entirely at the mercy of those about him. They may use the light extravagantly, especially in the early winter mornings, and incur a heavy account, which a small householder, at any rate, would be quite unprepared to meet. There can be no question that this has been the reason of much dissatisfaction in connection with electricity accounts.

2. The acquisition of a profitable class of consumers. The prepayment meter user, while only requiring a small number of lights, will probably be using them for three or four hours per day on the average. Owing to the comparatively high cost of the service and meter connections, the profit will be small, but the nature of the demand will tend towards improving the load factor at the central station.

3. Prepayment meters can conveniently be used in conjunction with a scheme of free-wiring. By adjusting the meter for supply at 1d. or 1½d. per unit more than the usual price, the hire of the wiring can be included and paid for with the charge for the current. Thus, if certain premises are wired at a cost of £4, at an annual rental of 15s., the additional charge per unit would be obtained by dividing the 15s. by the estimated number of units to be consumed. Assuming the number

of units sold during the year to be 180, the additional cost per unit would be exactly 1d., which amount would be added to the usual charge.

4. By a combined scheme of prepayment meters and free-wiring, it would be a fairly feasible enterprise to extend electricity cables into the artizan and poorer districts of the town. Without such a scheme, the demand, among such a class of customers, would be too precarious for many years to justify the adventure. The advantages of free-wiring would readily be appreciated by the wage-earning public, and as the class of electric light fittings would not be of an expensive order, the business to be done should be considerable and remunerative. By the adoption of these meters, the electric light would, no doubt, be brought into practical patronage by the working man, and it would then become more truly the "poor man's light," which, in a prophetic spirit, it has already been christened.

Disadvantages.—The disadvantages which may arise in connection with the use of prepayment meters are not numerous. They may be summed up as *(a)* failure of the switch to "cut-off" the supply when the coin's worth of electricity has been consumed; *(b)* the possibility of metal discs being dishonestly used to work the meter, in place of coins; *(c)* the increased comparative cost of the prepayment meter and the house service; *(d)* the increased charge per unit which is usually made when prepayment meters are used.

To these objections, the broad general reply is that they are trifling, compared with the great advantages just enumerated. The percentage of failures of the switch to "cut-off" the supply is not likely to be of any appreciable magnitude, if the prepayment meter employed is of a strong and simple design, with a positive action. With a defective meter, there is also always the greater and counter possibility of the lights being switched out before the coin's worth has been consumed; but in that case, of course, the consumer would not be long before calling the attention of the supply authorities to the matter.

The substitution of metal discs for coins, or other fraudulent means of obtaining a supply of electricity, is, in the case of the prepayment

meter, quite different from ordinary slot machines placed at railway stations and other places for the use of the general public. In the latter case the fraud is most difficult to detect and to prevent, whereas in the former the user would stand self-convicted, and would be held liable for the represented value.

To the increased comparative cost of the meter and house service, is due the slightly increased charge per unit which has to be made. The consumer, however, as a matter of fact, does not notice, and certainly does not feel, the small extra cost of electricity when paying for it, a penny or a shilling at a time, as he would do if the account were rendered quarterly.

The cost of the house services may also, in some cases, be considerably modified by simply putting in one service for a row or block of houses, and running a sub-main from the main fuse boxes to the entire block.

Cost, Construction, and Design.—The following points should form the chief characteristics of the prepayment meter, viz. :—

1. The cost should, if possible, not be more than £2, nor in any case should it exceed £3.

2. The construction should be of a strong and mechanical nature.

3. It should be thoroughly reliable and accurate.

4. It should be designed to give a minimum amount of vibration when inserting the coin and turning the handle, or other means of operating the mechanism.

5. It should be practically impossible to tamper with the meter in any way.

6. It should be equally suitable for alternating or continuous current systems of supply.

7. It should not be affected by barometric changes, nor by changes in the humidity or temperature of the air.

8. It should be designed to take several successive units of payment at one time, so that the user may provide against possible want of cash in the immediate future.

Forms of Agreement for a Combined Scheme of Prepayment Meters and Free-Wiring :—

Landlord's Agreement.

Memorandum of Agreement made this day of One thousand eight hundred and ninety- between the Mayor, Aldermen, and Burgesses of the Borough of (hereinafter called "the Corporation") of the one part, and

of

(hereinafter called "the Landlord") of the other part.

Whereas the Corporation has, with the consent of the Landlord, and at his request, and by agreement with the occupier or occupiers, erected and fixed, or caused to be erected and fixed, on the premises particularly described in the schedule hereto, the appliances and fittings requisite for the purpose of lighting the said premises by electricity. Now this agreement witnesseth that in consideration of the Corporation having so erected and fixed the said appliances and fittings on the said premises, he, the Landlord, doth hereby for himself, his heirs, executors, administrators, and assigns, covenant with the Corporation, that neither he or they nor any superior landlord or landlords of the said premises will, at any time hereafter, while the said appliances and fittings or any of them are in or upon the said premises, distrain or execute, or cause or permit to be distrained or executed, any legal process upon the said appliances and fittings or any of them, and that they and each of them will permit the Corporation, or their officers, to enter upon the said premises at any reasonable time during such time as aforesaid, to

repair or to remove the said appliances and fittings or any of them from the said premises.

As witness, the hand of the Landlord and the hand of the duly authorised officer of the Corporation, in that behalf.

THE SCHEDULE ABOVE REFERRED TO.

Description of Premises	Name of Present Occupier

Signature of landlord

Witness

Inspector's signature

Tenant's Agreement.

Terms and Conditions for the Supply of Electricity to Consumers by Prepayment Meter:—

1. The prepayment meter, with all such attachments, wirings, and fittings thereto, as may be required by the consumer, shall be fixed by and remain the property of the corporation.

2. The consumer shall not permit the meter attachments, wirings and fittings, or any part thereof, to be altered, removed, distrained upon,

or interfered with by any person other than the servants of the corporation.

3. In the event of any damage or injury occurring to the meter, attachments, wirings, or fittings, or any defect being discovered which may hinder the proper working thereof, the consumer shall give immediate notice to the corporation, and if such damage, injury, or defect be caused by any wilful act or default of the consumer, the consumer shall pay to the corporation the cost of making good or repairing the same, and the consumer shall keep supplied proper incandescent lamps, in place of any broken or worn out during the continuance of this agreement.

4. The consumer shall pay to the corporation for the electricity supplied at the rate of   pence for each Board of Trade unit, as registered by the index of the meter.

5. The payment shall be made by the placing of British pennies in the prepayment-box attached to the meter for that purpose, and for the safe custody thereof, the consumer shall be accountable to the corporation until the money shall have been collected by the corporation officers, and the official printed receipt in discharge given therefor.

6. In case of any defect or failure in the working of the automatic arrangement of the meter, or if, from any cause, the amount of the pence deposited in the prepayment-box is found to be less than the sum which ought to be there, having regard to the quantity of electricity registered by the index of the meter, the consumer shall be chargeable for the quantity registered by the meter.

7. If, upon collection of the money in the prepayment-box, the same shall, from any cause, be found insufficient to provide the sum due, the consumer shall forthwith, on demand, pay the deficiency to the corporation officers.

8. The officers of the corporation shall, at all reasonable times in the day-time, have free access to the consumer's premises, for the purpose of inspecting, repairing, or otherwise dealing with the said appliances and fittings.

9. This agreement may be determined by the corporation at any

time giving five days' notice in writing to the consumer, or sending such a notice by post, addressed to him at the premises mentioned below.

If the consumer commits any breach of this agreement, the supply of electricity may be discontinued without notice, and the fittings removed.

The consumer shall give to the corporation notice in writing of the termination of his tenancy of the premises where the electricity is being supplied, at least five clear days prior to the termination thereof, or of his intention to determine this agreement.

10. All notices on the consumer's part referred to herein to be sent by post.

I, the undersigned, do hereby request the corporation to supply me with electricity by prepayment meter, with attachments, wiring, and fittings, at the premises held by me, and numbered , in the parish of , upon the above terms and conditions, which terms and conditions I hereby agree to observe and perform.

Dated this day of 189

Signature of consumer

Witness

Types of Prepayment Meters on the Market.—There are very few types of prepayment electricity meters on the market at the present time. Those which may be considered sufficiently satisfactory for general adoption, may be divided into two classes, viz. :—

1. Lamp-hour or ampère-hour meters.
2. Prepayment attachments to ordinary electricity meters.

The following are descriptions of each type of meter respectively :—

Lamp-Hour or Ampère-Hour Prepayment Meters.—This type of meter is made by the Rochdale Electric Company, Limited, and is the invention of Mr. William D. Watson (Watson and Humphrey's Patents).

The object is to register, in stated equal periods, a given amount of electric current on prepayment, by the insertion of one or more coins.

The following, briefly, are the chief points claimed :—

A definite measuring device, vigorous and strong, indicated at D3, B3, C3 (Fig. 19), very easy to calibrate.

A device indicated at G and E (Fig. 19), allowing the consumer the opportunity of storing up from one to fifteen pennyworth, according to the price to be charged for the current.

A cut-out device, four-fold in its action, indicated at N, E22, E8 and Ex (see Fig. 19), the operation of which prevents the consumer from extracting an unlimited amount of current over and above the meter's maximum carrying capacity—for instance, the connecting up of a small electric motor.

A face-dial (E1), indicating the amount of lamp-hours still to the credit of the consumer.

A continuous registering dial (L1), acting as a check on the collector.

A device (Fig. 25) for regulating the number of lamp-hours to be given for each coin. This regulation may be effected by any authorised person as may be required, without displacing the meter from the wall or bracket.

A device indicated at I, I1 (Fig. 19), to arrest the pendulum on breaking of the electric current, whereby the same becomes self-starting on completing the electric circuit.

Causes of error existing in most meters, due to friction of brushes, counter electro-motive force, sluggish action of governing motion, due to friction, running on the shunt, and the use of permanent magnets, have no influence on this meter.

The absence of shunt or secondary coils prevents the expenditure of current when the circuit is broken. From this cause alone the annual loss, as in most types of motor meters, varying from 5s. to 40s. per meter, is entirely prevented, the ampère meter, in this case, being connected in series.

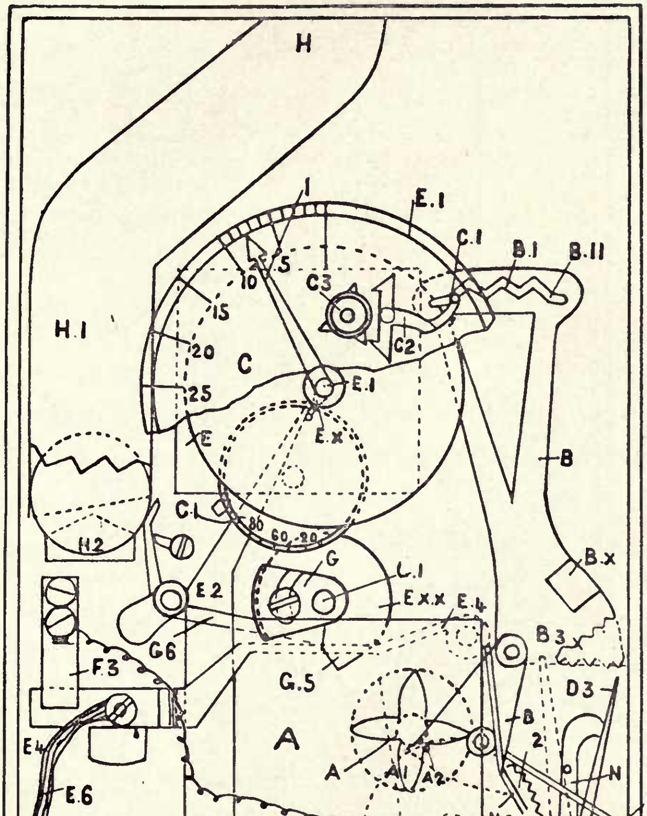
H
H.1
I
E.1
C.1
B.1
B.11
C3
C2
5
10
15
20
25
C
E.1
E.x
E
B
H2
C.1
80
60
20
G
C.1
E 2
E.x.x
E.4
G6
F.3
G.5
B 3
D3
A
E4
E.6
B
2
N
A
A1
A2
N.2
B.13
E.21
N.1
f.1
E.8
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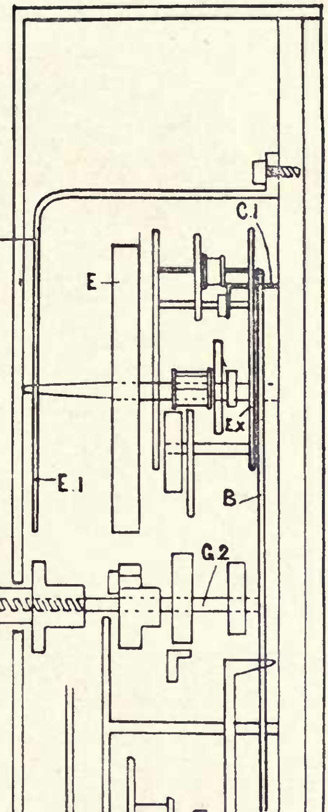
Fig. 19.


E
C.1
E
E.x
G.1
E.1
B
G.2
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K.1
W
K.x
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A.x
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Fig. 20.

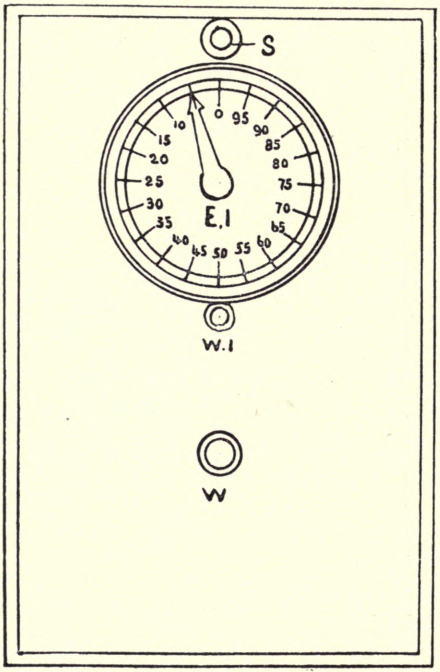

Fig. 21.

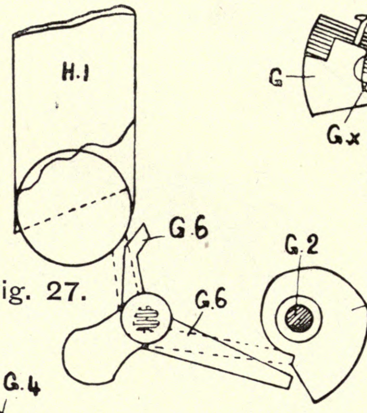

Fig. 27.

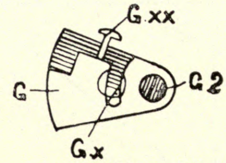

Fig. 25.

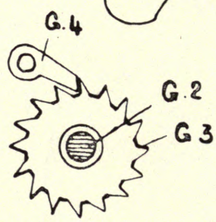

Fig. 28.

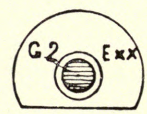

Fig. 26.

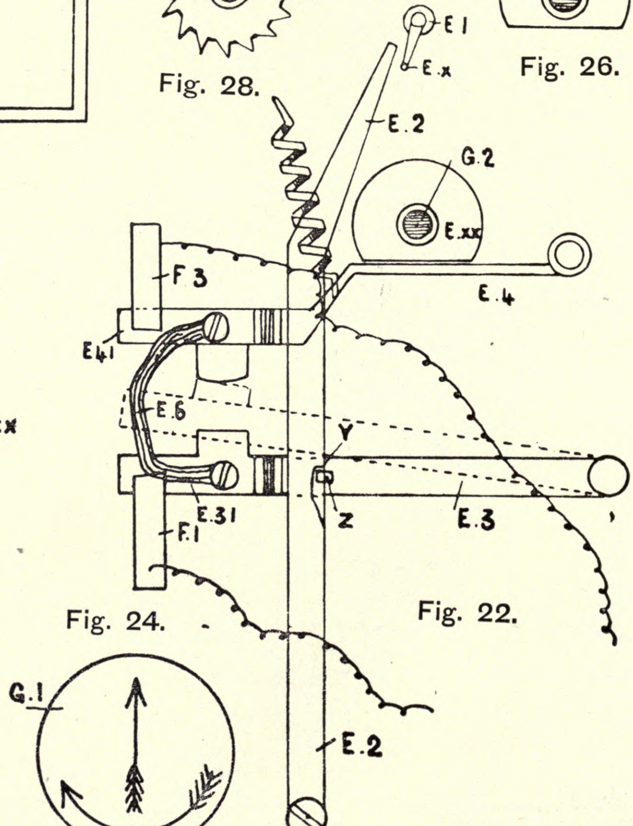

Fig. 24.

Fig. 22.

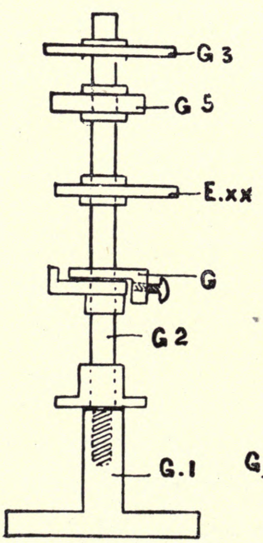

Fig. 23.

The power required to operate the cut-outs and propel the dial-finger is not given by the clock A, nor by the expenditure of excess current. The necessary power for this is stored up by the winding of the clock C, which is done about once every 1,800 lamp hours by the collector.

The action of the clock A, and the governing lever B, is not to propel directly, but to allow the escapement C2, C3, to drive the disc E and dial-finger by the action of the mainspring of the clock motion C.

Description :—A (see Fig. 19) is an ordinary pendulum clockwork movement of strong type, and upon the arbor A is fixed a cam A1 of such form, that as the said arbor A revolves, the cam A1 will move the pin A2 on one end of the governing lever B. The other end of this lever B is provided with a zigzag slot B1, into which engages the pin C1 on the escapement lever C2.

C is an auxiliary clockwork movement, and it will be seen that the effect of rocking the vertical lever B, the pin C1 will be caused to rock, and in this way the escapement wheel C3 will be allowed to move a tooth for each incline of the zigzag slot B1, and the dial-finger 1, will be caused to move, through a train of wheels, towards the zero on dial E1.

The lever B is caused to oscillate once every five minutes, so that it will be seen that if one light only is switched on, the integrations of measurement will be two (one forward and one backward of the escapement lever B) in the five minutes. If six lights (the maximum carrying capacity of the meter under consideration) are switched in circuit, the integrations of measurement become twelve in five minutes. That is to say, the measurements are of equal integration—one every twenty-five seconds.

In order to regulate the extent of stroke of the lever B according to the amount of current used, or to stop the action of the lever when current is cut off, we provide the lever B with graduated steps indicated at B3, and we fit to the apparatus an ampère meter or its equivalent with a finger D3 in such a position, with regard to the last-named cam

surface B3, that as the position of the finger D3 changes according to the amount of current being used, or according to the stoppage of the current altogether, the pin A2, on the end of lever B, can be held partly or almost out of reach of the cam A1 (worked by clock A), and consequently the action of the escapement C2, C3, will be repeated more or less frequently, or will be stopped, and will quicken or retard or arrest the motion of the indicator and cut-out disc E. The form of ampère meter preferred is indicated by a coil D and armature D1 (see Fig. 19).

Every lamp that is lighted causes the coil D to attract its armature, and the finger D3 is moved a step further from the fulcrum of the lever B, and allows the pin A2 to move further from the arbor A, causing the escapement motion at C3 to move another tooth.

It should be pointed out here, that the accuracy of measurement does not depend upon the ampère meter attracting the pointer D3 in exactly equal distances for each lamp of equal power that may be switched on. The steps at B3 are easily cut to correspond with the movements of D3.

As the dial-finger 1 works to zero by the action of the escapement C3 on the dial E1, the pin Ex (see Fig. 22) comes into contact with the lever E2, and, forcing it away, causes the catch Z to spring out of the notch Y, and the electric circuit is broken at F1.

Should it be attempted by the consumer to extract more current out of the meter than its maximum carrying capacity—six 8 candle-power lamps—the coil D will attract the armature D1 to such an extent, that the part B3 will miss the finger D3 altogether, and the lever B will fall suddenly towards the centre of the cam A1, and an arm B13 thereon will come in contact with a small weighted balancing piece N, pivoted at N1 to the end of the cranked part E21 of the switch-lever E2, and throw it into gear with the teeth of the wheel 2 of the clockwork A. By the lifting action of the wheel 2, the catch Z will be tripped, cutting out the lights.

As the pointer 1 will now be at zero, the insertion of another

coin at H, passing through the shoot H1, the bell crank lever G6 will be displaced, thus allowing the knob G1 (see Fig. 20) to be turned. The incline on the cam G5 (see Fig. 27), displacing the lever G6 still further, causes the coin to shoot over H2 into the receptacle below (not shown in the drawings), and the circuit is completed.

The disc E is set back by the turning of the knob G1, and the amount indicated by the finger 1 in front of the fixed dial E1, shows clearly and readily the amount of current paid for and unused.

The turning of the knob G1 rotates the shaft G2, upon which is fixed the split-friction sector G (shown more clearly in Figs. 23 and 25), and which is prevented from rotating backwards by the action of ratchet wheel and fixed catch G3, G4 (Fig. 28).

The sector G, in rotating, engages the periphery of disc E, setting back the pointer 1 a given number of lamp-hours.

This sector G is made in two parts (see Fig. 25), held together by a screw Gx, the opening or closing of which determines the length of arc to engage the disc E, and thus the amount of current to be supplied for one coin is fixed.

The shaft G2 is provided with a flat-sided disc Exx (see Figs. 22 and 26), which causes the lever E4 to be depressed on revolving G2, and the circuit to be broken at F3. The action of this is to prevent the knob G1 being left only partly turned and the sector G jambed with disc E, and so prevent the escapement C2, C3, from working.

The knob G must be turned one complete revolution in the direction of the hands of a clock, till the arrows are in the position indicated in Fig. 24.

A piece of flexible wire E6 connects the two levers E31, E41 (see Fig 22). These levers are both insulated with ebonite in such a way as to prevent the current from passing into the works or frame of the meter.

To prevent the stopping of the clock A, which may otherwise be done by inserting the winding-up key at W (see Figs. 20 and 21) and firmly holding same against the action of main-spring, we provide a lip

E22, situated over the key shaft Kx (Fig. 19), connected to the cut-out lever E2 in such a position that when the key is inserted this lip will be raised and the circuit broken.

The clock A may then be wound (usually this is done once a week), after which a coin must be again inserted at H and the knob G1 turned (giving the stated number of lamp-hours) before the circuit can be completed.

To prevent the clock A stopping by the running down of mainspring, a screw E8 is fixed on the cut-out lever E2, against which the mainspring M will impinge and trip the catch at Z, causing the circuit to be broken.

Each time the circuit is broken, and from whatever cause, the lever E51 (Fig. 19), which is joined to E3 by its sudden movement to the left, liberates the spring-catch I, and causes it to engage in one of the fine teeth I1, fixed at the underside of pendulum Ax, and arrests the latter in the position indicated on the drawing. On the circuit being made by the depression of levers E3, E4 (Fig. 22), the pendulum Ax becomes self-starting.

The meter is enveloped in strong dust-proof cast-iron case, and the works cannot in any way be tampered with from outside.

Fig. 21 is a front view of meter when sealed up. S indicates where the seal is attached.

Points of advantage claimed :—

Can be made for alternating as well as continuous currents.

Starting with a very small current, and perfect constancy at zero.

Accurate within 2 per cent. at all periods and at all temperatures.

Independent of direction of current.

No work for current to do.

Mechanism which relieves the current from doing any work.

No permanent magnets.

No mercury contacts.

No shunt coils.

No liquids used.

Cheap in cost.
Costs nothing for maintenance.
No fall in voltage.
Accuracy unaffected by temporary excess currents.
,, ,, local short circuits.
,, ,, outside influence.
,, ,, barometric changes.
,, ,, vibration, within wide limits.

The Long-Schattner Prepayment Electricity Meter.—This is another type of the ampère-hour meter which is now being placed on the market. It has already met with considerable success, the Norwich Electricity Company being the first to adopt it.

A short description of the principle of the Long-Schattner Meter is appended, and it is illustrated in Fig. 29.

Fig. 30 shows the principle diagrammatically. A is a lever pivotted at X. At the far end of the lever is suspended a copper-plate B, which is immersed in a solution of copper sulphate. The box D is also of copper, and forms the negative plate or kathode. C is a weight to balance the other side of the lever. K and E are cups to hold respectively the coins and standard weights which the collector replaces instead of the coins. F1 and F2 are mercury cups. F1, the front one, being filled with mercury; F2, the back one, being half filled with mercury, and filled up with creosote oil. H1 and H2 are contact pieces forming a bridge across the mercury cups, which bridge is fixed on the lever. R1 is a main resistance, across which the volta-meter goes as a shunt, and R2 is a large resistance going from one mercury cup to the other.

The plan of connections is shown in Fig. 31.

When the lever is "up," it will be seen that the mercury connection in cup F2 is broken, and the current has to pass through resistance R2. The course of the current is as follows:—

1. When lever is "down." Entering at O to mercury cup F2, H2, from there part goes through connection to plate B, across to box

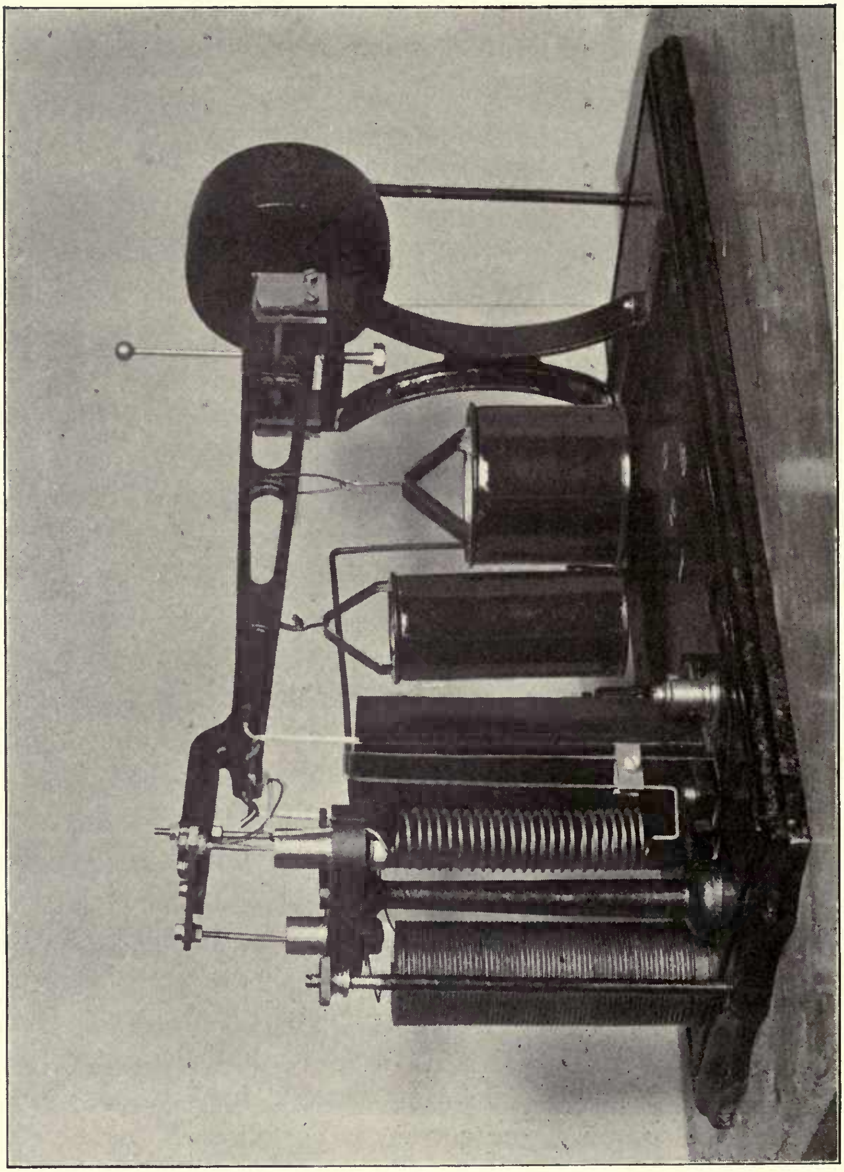

Fig. 29.

D, depositing copper from B to D and out to Y; the other part the main current, goes from H2 to H1, to F1 through resistance R1, joining the other part at Y and out at terminal Q.

2. When the lever is "up." Contact piece F2 is out of the mercury, and the current has to take the course through resistance R2, which causes a very large drop in voltage; part again through R1, and the other part up H1 to plate B and D, and joining the other part at Y again.

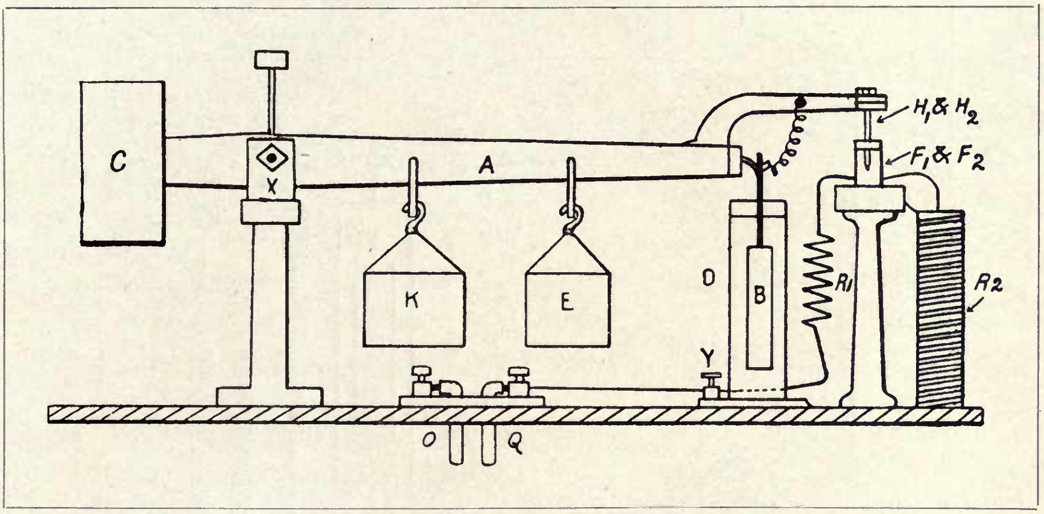

FIG. 30.

From the above, the complete action of the meter can be seen. The lever is overbalanced, say, to start with. A coin has to be inserted, which brings the lever over again, establishing a short circuit across the mercury cups. It keeps in this state until the amount of electricity equivalent to that coin has been used, that is, until B is lightened enough to cause another overbalance, breaking H2 and F2, and forcing the current to pass through R2; thus the circuit is never actually broken, the lamps continuing to burn quite dimly, forcing the consumer

to insert another coin to get any appreciable light at all, whilst he has also to pay for the light he burns dimly, as that, too, goes as before through the voltameter, so that the next coin he inserts really pays for that light.

R2 is of considerable resistance; thus, with twenty 16 candle-power lamps, a drop of about 70 volts is obtained; with ten 16 candle-power lamps, 35 volts drop; with five lamps, 17 volts drop; and with two lamps, about 7 volts drop.

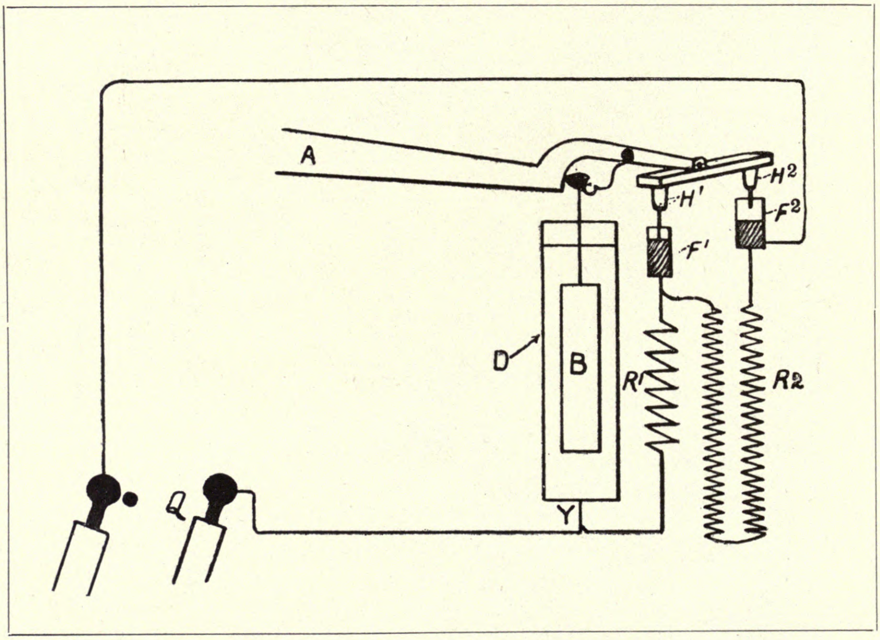

FIG. 31.

There are but few details to be explained. It has been found that the creosote in mercury cup, F2, is very effective. It causes a perfectly sparkless "break" and "make," even at full load, on a 220 volts circuit, and it also keeps the contact maker, H2, perfectly clean. It, of course, does not deteriorate, neither does the mercury, so that the cups need really very little attention when working.

By never completely cutting the light off, a considerable advantage is gained, as the consumer need not fear the annoyance of suddenly being put in darkness.

One copper plate and box will last 700 units, and then has to be replaced with a fresh plate and box, at a cost of five shillings. The box and plate are made easily detachable from the meter.

It has been found beneficial to pour a thin layer of ordinary machine oil over the top of the copper solution, thus preventing any evaporation. This does not affect the plate or box at all, the only precaution necessary being to rinse the box and plate with water when removing the solution.

Lastly, the proprietors of the Long-Schattner patents have decided to make their meter purely a silver one, that is, only silver coins (3d., 6d., and 1s.) being admitted. They have come to the conclusion, from the experience of the gas companies as well as from other sources, that the consumer prefers a larger amount than a pennyworth at a time.

Each meter is supplied with standard weights to cover the life of a plate, viz., 700 units at 6d. per unit, these weights to be gradually placed in the standard weights pan by the collector as he extracts the money.

The meters are calibrated to any required rate per B.T.U.

The copper sulphate solution is of 1,115 specific gravity, and is made up of 1 per cent. sulphuric acid and 99 per cent. water.

One advantage of the Long-Schattner meter, is the adjustment whereby the consumer gets full value, even in the event of worn, and hence short-weight coins being used. This is achieved by the collector on each examination of the meter placing in the special pan the standard weights equivalent to the value of the coins. Users of the penny-in-the-slot gas meters complain that with these coins they do not get their full value of gas, but with the Long-Schattner meter this complaint cannot exist.

Prepayment Attachments to Ordinary Electricity Meters.—These attachments are made by the Penny-in-the-Slot Electric Supply Syndicate, London, under the patents of Mr. Charles Orme Bastian. The prepayment

electric meter devised by Mr. Bastian has gone through quite an evolutionary process before arriving at its present form, the chief modifications tending towards a simplification of the instrument.

This prepayment arrangement does not imply a special form of meter, for the device can be attached to any of the well-known types

Fig. 32.

of meter. The illustrations by which we shall strive to explain the working of the instrument show the prepayment mechanism applied to a Thomson-Houston watt-meter. The operation of the instrument, by means of a coin, is an interesting and ingenious one. Until a coin is inserted, the handle which projects from the cover is free to move; a coin, when passed through the slot, falls into a groove, and forms a rigid

connection between the handle and the interior mechanism, and a turn of the handle switches on the current. The arrangement of the meter will be better appreciated by referring to the detailed parts. Fig. 32 shows the meter and prepayment attachment entirely enclosed, which is the form in which the mechanism will be usually sold. Fig. 33 is a front view of the meter, the only features to be noticed here being the coin receiver or shoot down at O, and the pointers N N, the exact function of which

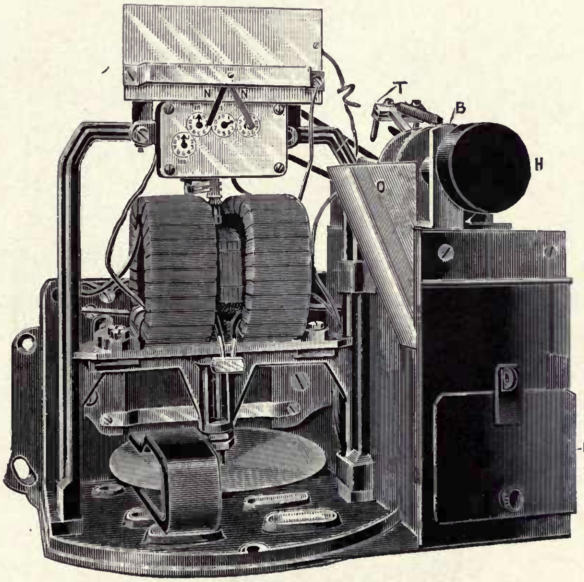

FIG. 33.

will be referred to subsequently. Fig. 34 gives a detailed view of the prepayment mechanism seen from the back of the meter. We will now follow the action of the apparatus. Upon the insertion of the coin at B, which makes a mechanical connection, the handle H is turned. One result of this is to operate on the pivotted end of the switch T which is depressed into the mercury cups M, thus completing the circuit through the meter. The switch is held in the mercury cups, against

the tension of a spring, by means of a clutch D. The turning of the handle does more than merely put the switch on. In fact, the operation that we are about to describe is probably the most important in the complete action of the mechanism. Above the dials of the meter (Fig. 33) will be observed two pointers, and the relation of these to one another

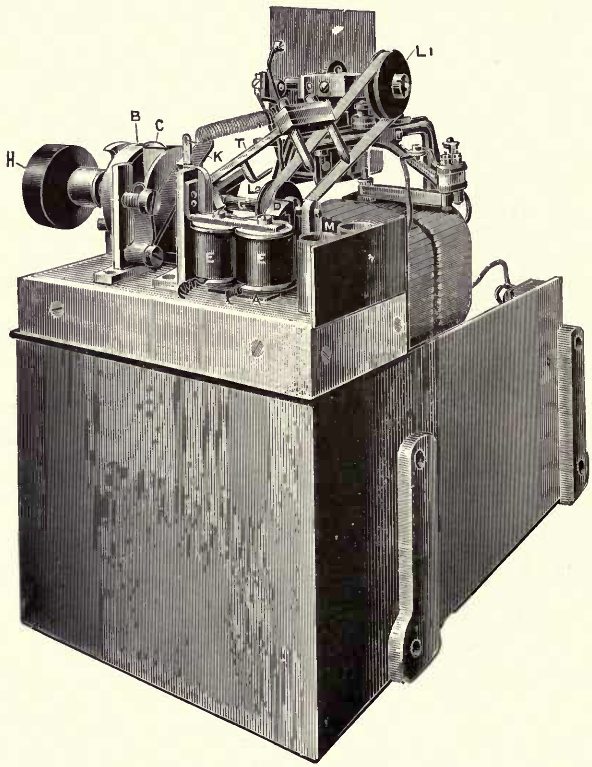

Fig. 34.

is very important. The handle H, being in connection with a rod G, its movement will cause a partial revolution of the pulleys L1 and L2. These pulleys are connected together by means of a miniature raw hide belt; pulley L1 is mounted on an axle, which carries one of the pointers already alluded to. It will be seen, therefore, that when the handle is

turned, one of the needles, through the medium of the pulleys, is moved away from the other pointer, the exact distance of its movement being pre-determined.

The second pointer is geared to the train wheels of the meter, and when the switch has been put on by the agency of a coin, and the meter commences to register, then the second pointer travels slowly after the first one. The exact distance it has to traverse before it overtakes the first pointer is a measure of the current consumed; in fact, the first pointer is caught up by the second pointer in a time inversely proportionate to the amount of current flowing through the meter. The distance the first is separated from the second is determined by the gear wheels, which are proportioned according to the price per unit, and the value of the coin with which the mechanism is intended to be operated.

The more coins that are dropped in, up to a certain limit, the further the first pointer will be separated from the second, and they will be a proportionately longer time in coming together. One side of the first pointer is insulated, so that it can come in contact with one side of the second pointer with impunity.

The other side, however, carries a platinum contact, and when the second overtakes it and comes in actual contact, a current of electricity flows round the electro-magnet E, the armature of which is immediately raised, pulling the clutch D away from the switch T, which immediately flies into the "off" position.

Electrolytic Prepayment Meter (Parson's pattern, Fig. 35).—This apparatus is a combination of the Bastian electrolytic meter and the prepayment attachment (same as used on motor meters). Each time a coin is inserted and the handle of the attachment turned, a contact is broken in a shunt circuit, and the lights turned on. The current, passing through the meter, decomposes the water therein, and the consequent reduction in the volume of the electrolyte causes the contact to be again made in the shunt circuit, thus causing a current to flow through the electro-magnets in the attachment, which withdraws a clutch from a switch, and allows the latter to fly into the "off" position. In the figure,

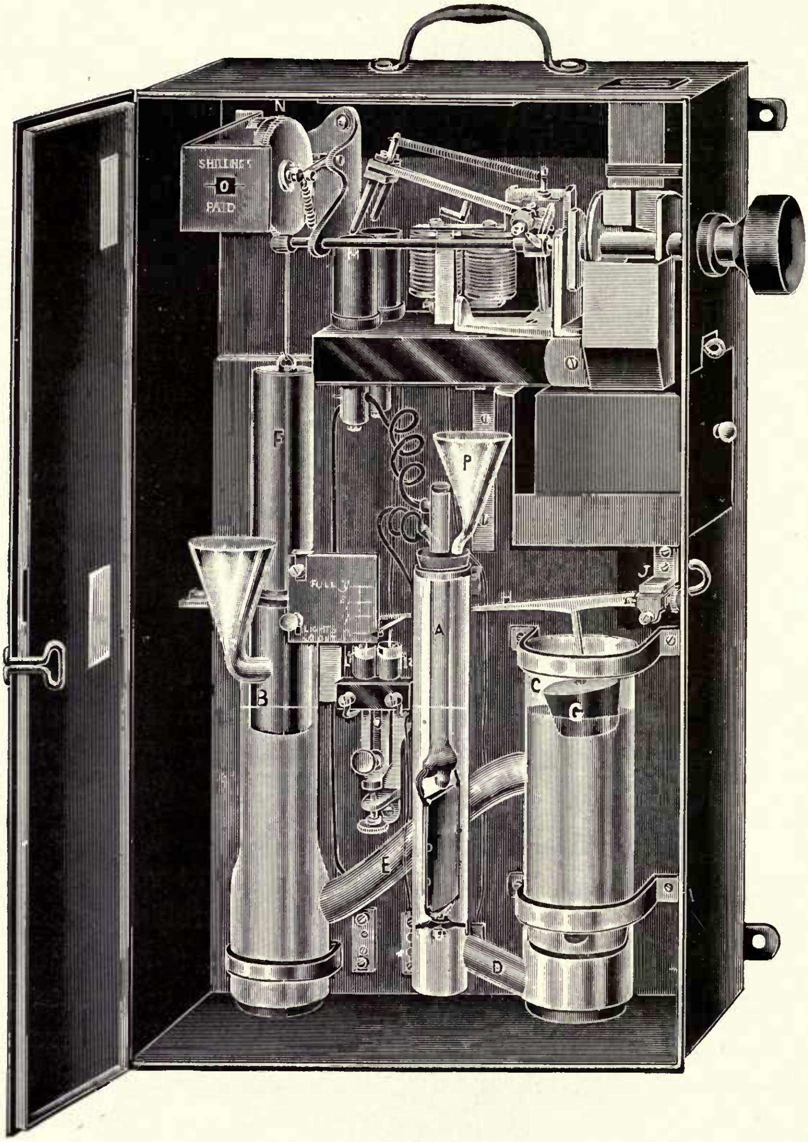

FIG. 35

A, B, and C are glass vessels connected together by tubes D and E, E connecting B and C, and D connecting A and C. F is a cylindrical plunger, which can be lowered into or raised out of the vessel B, by means of the attachment. The vessel A has electrodes, E1 and E2, arranged within it, and contains the ordinary electrolyte (sulphuric acid and water); and C is also half filled with this electrolyte, the upper half being filled with oil, which, of course, floats upon the surface of the electrolyte. The oil, on being poured into the vessel C, runs through tube E, also filling vessel B. G is a float, on the top end of which is connected a rod H, pivotted at J, and carrying two dippers, K1 and K2, which are adapted to connect together the mercury cups, L1 and L2, which are in circuit with the electro-magnets on the attachment.

The operation of the meter is as follows:—When a coin is inserted in the attachment and the handle turned, this revolves the shaft M, which in turn revolves the pulley N, thereby lowering the plunger F into the vessel B, which causes level of the liquids in A, B, and C to rise. The rising of the liquid in C raises float G, thereby causing the dippers, K1 and K2, to be lifted out of the mercury contained in the cups, L1 and L2; the turning of the attachment handle also switches on the lights, and the current is thereby caused to flow through the electrolyte in the tube A. Electrolysis is thus produced, and the consequent reduction in the volume of the liquid causes float G to gradually descend, and eventually bring dippers, K1 and K2, into contact with the mercury cups. This immediately causes a current to flow round the electro-magnets on the attachment, and the lights are thereby switched off. The plunger F is adjusted to be lowered each time the attachment is operated, by an amount which will cause the dippers, K1 and K2, to be raised from and kept out of contact with the mercury, L1 and L2, during the passage of a shillingsworth of current, or any other value for which the attachment may be arranged. Obviously, two or more coins may be put into the attachment in quick succession, as on each operation the dippers, K1 and K2, will be separated further from

the surface of the mercury, and a proportionately greater quantity of current will have to pass through the meter, before the lamps are again switched off by the contact of the dippers and the surface of the mercury. The dial in front of pulley N is arranged to indicate the number of times the attachment has been operated, and therefore how many shillings have been paid. The tube C is arranged to hold an amount of water (electrolyte) that will be decomposed by the passage of 20s. worth of current, after which the apparatus needs to be reset, which is done by winding up pulley N until zero appears on the dial, and water is then poured into A, through funnel P, until the pointer fixed to rod H also indicates zero on the scale over the mercury cups.

SECTION IX.

SIDE STREET LIGHTING.

There can be no more fallacious statement than that which is sometimes made, that a municipality which adopts the electric light for its own offices and for public street lighting, is necessarily entailing a considerable increase in the rates. Such an impression has undoubtedly gained ground, through the increased cost of electricity when compared with gas in most towns, during the first few years of electricity supply. In those early days the long-hour consumer was practically unknown, and the charges then made for lighting streets by electricity were similar to those made to the ordinary consumer. But in street lighting it is obvious there exists a constant and uniform demand for a supply of electricity, extending over 4,015 hours, out of a possible 8,760, in the year. This means an average demand for eleven hours per day, and the comparison between the cost of gas and electricity for such a purpose is clearly illustrated in Table VI. Further details, relating to the value of the long-hour demand are fully dealt with in Section III.

Much improvement has recently been made in lighting streets by gas. There are, for instance, incandescent gas mantles, argand burners, a combination of several lights in one lantern, and other forms. Many of these improved methods, however, have only been applied to principal streets and main thoroughfares, the side or branch streets, especially in residential neighbourhoods, still remaining in comparative darkness, with

the old-fashioned single jet of flickering gas light. The cost of lighting streets by gas is very difficult to ascertain accurately. Such details are involved as the life and efficiency of mantles, the cost of lighting up and turning out, cleaning, &c. In addition to all these we have to take into account the important circumstance that the constancy of the candle-power is very little to be relied on. There should be no difficulty in showing that, with an average demand for electricity for eleven hours per day, it is impossible for gas to compete in point of cost, even where the municipality itself owns the gas undertaking. In those cases, however, where the municipality does not own the gas undertaking, but pays a private company out of the rates, for lighting the streets, there is an additional incentive to adopt electricity as the illuminating power. In regard to general satisfactoriness everything is in favour of the electric light.

It is not proposed, in considering this subject, to make more than a passing reference to the lighting of streets by arc lamps. It may be taken for granted, that it has already been amply proved, that arc lighting is the most satisfactory, the most economical, and in fact the only practically possible way of lighting the main streets of any town, and that all other methods will shortly become obsolete. It may also be accepted as a fact, that the lighting of side streets by incandescent gas mantles, is much too expensive a method, when compared with the facilities for handling incandescent electric lamps. Hence we may assume that, where electricity mains are laid, all side streets should be lighted by incandescent electric lamps.

There are several methods of connecting street lamps to the mains, but this is a matter more closely related to the engineering side of the question, with which this work is not concerned. Even the commercial aspect may be summed up in the statement that the electricity works has an exceptionally long-hour consumer in side street lamps. It will be as well, however, to briefly consider the following phases of the subject :—

1. The cost of supply.

2. The extent to which incandescent electric lamps have been adopted for side street lighting.

3. The forms of street lanterns found most appropriate when replacing existing gas lanterns, and also with new designs.

The Cost of Supply.—Before we can estimate the relative cost of gas and electricity supply, some basis must be used which will represent as fairly as possible the *average* prices for these commodities throughout the country. We will assume gas to be 3s. per 1,000 cubic feet, and electricity 2d. per unit. (See Table VI., page 38.) It must, then, be borne in mind, that the gas light proposed to be replaced is the ordinary 5 cubic feet per hour—16 candle-power light. The electric lamp may be taken at 3·5 watts per candle-power, for an average life of at least 1,000 hours. Dealing only with the energy consumed, the following comparison is obtained, viz. :—

GAS.

16 candle-power light at 5 cubic feet per hour, burning for 4,015 hours = 20,075 cubic feet at 3s. per 1,000 cubic feet = ... £3 0s. 2½d.

ELECTRICITY.

16 candle-power light at 3·5 watts per candle-power per hour, burning for 4,015 hours = 225 units at 2d. per unit = ... £1 17s. 6d.

In addition to the saving indicated in the foregoing example, it is found in practice that, by the use of properly arranged reflectors, the light from an electric lamp is more effective than that from gas. The reflectors remain clean, as there is no smoke to blacken them, and the light is steady in the most stormy weather. In consequence of all this, it is possible, in some cases, to use only 8 candle-power lamps. In respect of other charges, such as capital cost, attendance, cleaning, repairs, &c., the expense will not differ materially from that for gas supply. Electricity has slight advantages in regard to some of these charges, and gas in regard to others.

Extent of Adoption (Bedford).—In this town the system of lighting side streets by incandescent electric lamps has been generally adopted. There are already 480 lamp columns in use, each with two lamps, as shown in Fig. 36. The candle-power of these lamps varies from 8 candle-power to 100 candle-power, each according to the position of the column and the nature of the street. The columns are usually from fifty yards to sixty yards apart, and the lamps are connected in parallel, off special

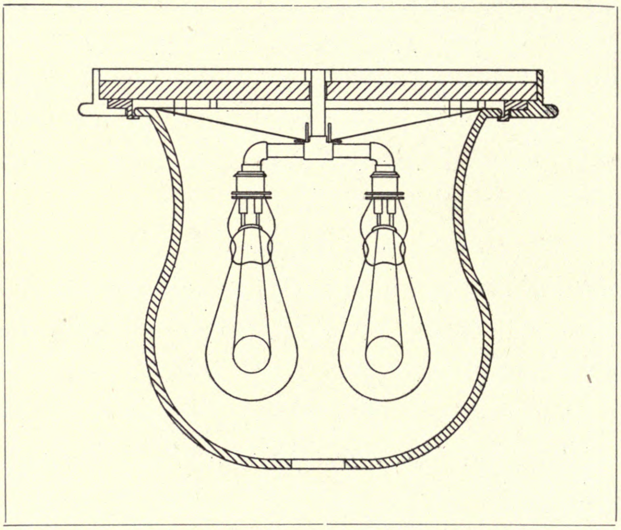

Fig. 36.

mains. The price charged by the electricity committee is 3d. per unit, and this is found to be approximately the same as gas.

Bradford.—At the present time there are, in Bradford, only fifty street lamps fitted with incandescent electric lamps. These fitted lamps are situated in the district which is supplied with gas by a gas company, the central and original area of the city being supplied from the corporation's own gas works. As an illustration of the peculiar local conditions which sometimes exist, it may be mentioned that very little

electric street lighting has been done in Bradford, there being only about fifty arc lamps and fifty incandescent lamps in the city, and the reason is chiefly due to an anomalous arrangement in the municipal gas department. The corporation supplies from its own gas works the greater portion of the area of the city, and the whole cost of the public lighting by gas is defrayed entirely out of the profits of the gas department. In other words, the entire charges for street lighting are included as ordinary works cost of production, with the result that the price per 1,000 cubic feet to the consumer is, of course, higher than it otherwise would be. No lighting tax or rate is made on the general ratepayer. This supply of gas, for street lighting, if it were paid for in the usual way, would be equivalent to an additional revenue of £23,000 per annum. The difficulty which exists in the electricity department is to find payment for the electricity supplied for street-lighting purposes. Up to the present not one penny has been received. The committee are not anxious, and do not intend to suggest a special rate for electric lighting in face of the above facts. But to provide a large number of units, which have mainly the same tendency to lower the profits of the electricity department as in the gas department, and which would be actually paid for entirely by the private consumers of electricity, is not even a possible arrangement under the peculiar conditions of electric generation. There does not, at present, appear to be an immediate solution to the difficulty. The incandescent electric lamps used in the outlying district, supplied by the gas company already referred to, are of 32 candle-power or its equivalent. Different types of lanterns and reflectors are used, and two of these are illustrated in Fig. 37.

The lamps are run in parallel off the ordinary lighting mains, and the price paid per lamp per annum, viz., £2 12s. 6d., is the same price as originally paid to the gas company. The gas columns have been utilized, and their distance apart is about fifty yards.

Brighton.—Side street lighting has been developed to a greater extent in Brighton than in any other town. It is, in fact, due to the particularly forward policy of this municipality, that considerable attention

has been given to the design of special fittings for incandescent electric street lighting. The fittings generally used are shown in Fig. 38, although other designs are also employed, such as for lamps in the centre of cross roads, &c.

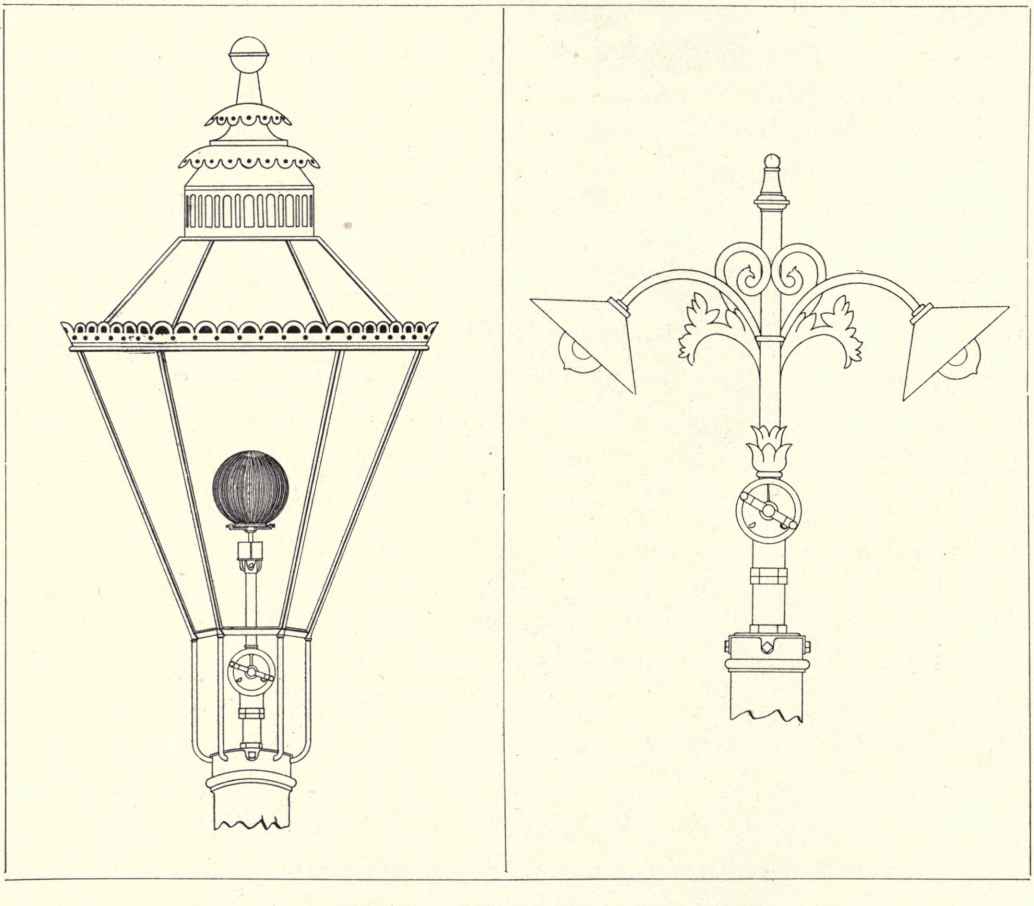

FIG. 37.

There are in Brighton 934 standards, each fitted with two lamps of 8, 10, or 16 candle-power. The standards are about 45 yards apart. The lamps are run in parallel, being supplied from the ordinary distributing mains with a switch to each standard, the lamps being switched

on in a similar manner to the ordinary method of lighting gas lamps. The prices paid by the street lighting department for these lamps are as follows :—

2—8 c.p.	... ...	£3	12s.	5d.	per annum.
2—10 c.p.	... ...	£4	1s.	8d.	,,
2—16 c.p.	... ...	£5	9s.	6d.	,,

It is estimated that these prices are identical with the price paid originally for gas lighting, but that 90 per cent. more light is now obtained. The low works costs of the electricity works in this town are well-known, and there can be no doubt but that this is very materially due to the extensive adoption of side street lighting.

Chelmsford.—For the lighting of some of the Chelmsford side streets, between 200 and 300 incandescent electric lamps are employed. Each lamp is for 110 volts, and is coupled on a parallel circuit with twelve lamps to a transformer. The greatest distance from a transformer to a lamp is 400 yards, the lamps being about 16 feet from the ground. Each lamp has a fuse. The distance between the lamps varies according to the importance of the roads—from 45 to 70 yards. Experience here has shown that 8 candle-power and 16 candle-power lamps are not of much use for street lighting unless two are fitted in each globe. The cost per annum was recently stated to amount to somewhere about £2 6s. 10d. per lamp.

Derby.—The number of lamps in Derby is fifty-eight, arranged as follows :—

4—5-light fittings ...	...	4—8 c.p., 1—16 c.p. each.
4—3-light fittings ...	...	3—25 c.p. each.
36—single-light fittings	...	16 c.p. each.

The lamp posts are 45 yards from each other, and the lamps are all run in parallel, the ordinary gas standards having been converted. The price paid per lamp to the electricity department is £1 17s. per annum, which is slightly cheaper than that paid for gas supply.

Hanley.—About fifty 16 candle-power to 32 candle-power lamps are used at distances of 75 yards apart, as previously existed with gas.

These lamps are supplied in parallel, off special mains, the switches being located at sub-transformer stations, or at the electric light station. Many different forms of lanterns and lenses have been tried, but preference has been given to the double-concave reflectors, with two 8 candle-power

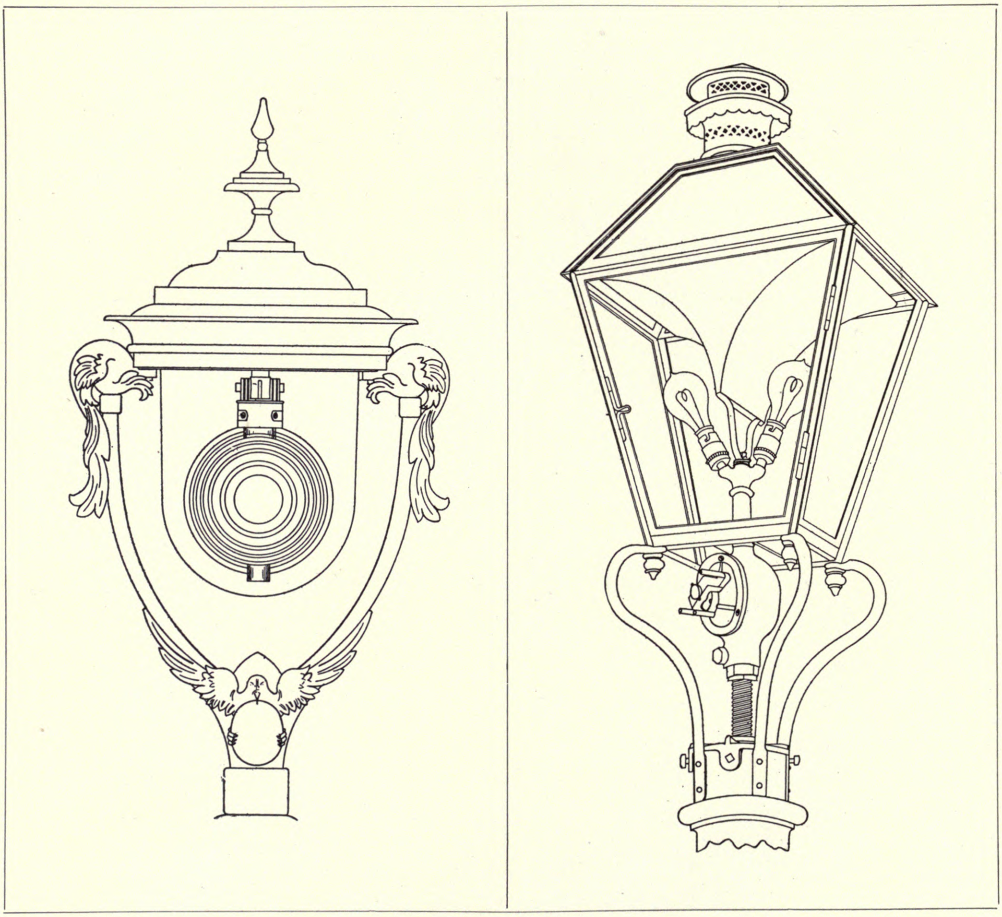

Fig. 38.

lamps, as used at Brighton. The original price charged by the gas company was £3 per lamp per annum, and this price is now paid to the electricity department. The electric lamps, however, give a better light.

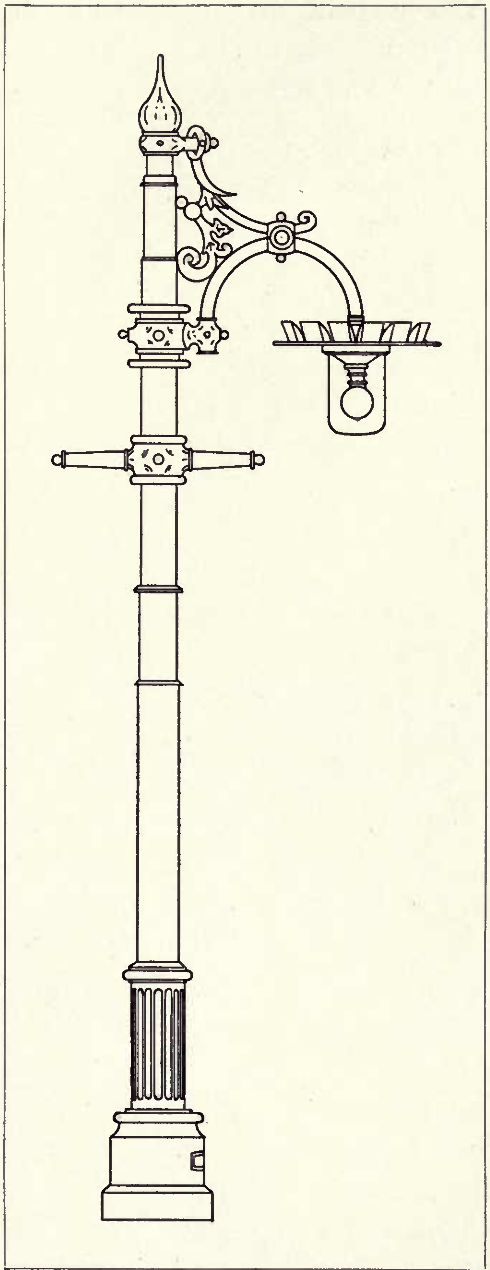

FIG. 39.

Kingswood and Keynsham.—At Kingswood there are 150 lamps, 16 being of 100 candle-power, 84 of 30 candle-power, and 50 small lamps varying from 16 candle-power to 25 candle-power. At Keynsham there are 88 lamps, 12 being of 50 candle-power, and 76 of 16 candle-power to 20 candle-power. The average distance of lamp posts from each other is 60 yards. At Kingswood 75 per cent. of the lamps run in series, and the remainder in parallel. At Keynsham all lamps are connected in parallel. These lamps are fixed on special posts of an ornamental nature, as shown in Fig. 39, and they practically take the place of arc lamps at a much less cost, at the same time giving ample light for the requirements of the district. The system adopted at Kingswood of running the lamps in series, is a resuscitation of the method tried some years ago at Barnet. Several advantages are claimed for this method, which, with the more perfect manufacture of the incandescent lamp, may now be more satisfactory than the earlier experiment. At Kingswood, the lamps are alight all night (3,750 hours per annum), and for the numbers and candle-powers

given above, the total sum of £644 15s. is paid. At Keynsham, the 88 lamps are alight from sunset to 11-30 p.m., and for this lighting the total sum of £161 15s. per annum is paid. The cost of gas in each of these places respectively was previously as follows :—

Kingswood.—150 gas lamps of 14 c.p. each ... £600 per annum.
Keynsham.—50 gas lamps of 14 c.p. each ... £110 ,,

Leyton.—The incandescent lamps are fitted in the ordinary gas standards with double-concave reflectors, and two 16 candle-power lamps in each lantern. The price paid is the same per lamp as for gas supply. The standards are 60 yards apart.

Portsmouth.—The electric lighting committee in this town are about to substitute electricity for gas in about 320 columns, and instead of using existing gas lanterns, a suitable ornamental casting will be adopted. The intention is to have two 8 candle-power lamps on each column, with opal shades. It is proposed to control the switching arrangements by automatic switches in the bases of adjacent arc lamp pillars. The charge for each column, as above, will be £3 5s. per annum, the corporation supplying everything.

Taunton.—There are about 150 side street incandescent electric lights in Taunton, the candle-power being 16, arranged either as two 8 candle-power or one 16 candle-power, according to the nature of the position and the gas fittings. They are fixed in the ordinary lanterns for gas, and the standards are about 60 yards apart. The lamps are run in parallel, and the charge per annum, including all renewals, is £3 per lamp. This is the same price as the gas company charged for gas lighting.

Whitehaven.—The number of incandescent electric lamps used for street lighting in this town is 442, which is the second largest number in the United Kingdom. A few of these are 8 candle-power (in courts and alleys) ; the majority are 16 candle-power, and about 14 are two 32 candle-power in one lantern. These are, of course, exclusive of the arc lights. The distance apart of the standards is about 50 yards,

on the average, and in no case does it exceed 65 yards. The method of running the lamps is two in series, 240 volts being the potential of the circuit.

No reflectors or lenses are used. These were originally put up, but were not considered entirely satisfactory. Plain glass globes are adopted, and these are fixed on top of the old gas columns, and the arrangement effectually keeps out all rain and moisture.

The street department of the corporation is charged 4d. per Board of Trade unit for all current passed through the central station meters for street lighting purposes.

The above charge, it is claimed, works out at rather more than 25 per cent. *below* the corresponding cost of lighting by gas, which the corporation bought from the gas company at 2s. 10d. per 1,000 cubic feet. It is also estimated that there is not less than twice the illumination from the electric lamps that there was from the gas lamps.

SECTION X.

FITTING UP AND MANAGING A CORPORATION SHOWROOM.

A SHOWROOM, for the purpose primarily of exhibiting and explaining the apparatus and other articles which are supplied to the public, will always be found to be an exceedingly useful, if not an absolutely necessary, adjunct to the ordinary works and clerical departments of a municipal electricity undertaking. During the first year of such a business, when the department will probably be fully occupied in connecting to the supply mains a great number of installations, and in providing a proper complement of machinery, mains, and meters, the subsidiary matters already dealt with in these articles may have to be postponed, and no necessity for a showroom would then exist. In the course of the second or third year, however, it will probably be found advisable, because advantageous, to start a showroom, the purposes of which will be entirely distinct from those of either the works or clerical departments.

The showroom section should be constituted and arranged to entirely relieve, if possible, the general clerical staff of the casual and extraneous, though no less important work, which would otherwise fall upon it. It should first of all, perhaps, be an office of general enquiry. By natural sequence it would thus become the medium for imparting information

gratuitously to the public, on all matters relating to the business of the whole department and the apparatus used. Such a medium may be said to be a recognised necessity.

Every municipal electrical engineer knows how many and varied are the enquiries made by consumers and prospective consumers, with reference to installation work, fittings, and electrical apparatus generally, of which, in the majority of instances, they have no knowledge whatever. It is this want of knowledge which is often taken advantage of by the unscrupulous wiring contractor, and hence, in the protection of their own interests, as well as in the interests of the consumer, stringent wiring regulations are, or should be, laid down by the corporation. Judging superficially, and they can judge in no other way, the public very often consider these regulations unnecessarily severe. There can be no doubt that a little explanation would throw great light on the subject, and the apparent unreasonableness of certain conditions and requirements to be observed in wiring work would soon disappear. The most appropriate means for such a desirable purpose is afforded by instituting a showroom to deal *inter alia* with this matter, and the discharge of this duty should form one of its principal features. It is far otherwise when such matters are left to take care of themselves, or at best, are left entirely to the clerical staff. As the old and wise saying has it, "What is everybody's business is nobody's business," and, in that case, enquiries are apt to be treated as no part of the business at all, and answers are given usually in a very perfunctory way. The tendency and temptation to give indifferent and incomplete information is almost sure to exist. At all events, the same satisfaction is not likely to be given as if the duty devolved expressly upon one official, specially engaged for the purpose.

The staff of a showroom need not be an expensive item : one man, and possibly an errand boy, will be found amply sufficient in most cases. This very modest equipment has met the requirements of gas companies' showrooms for the hire of gas stoves, &c., in cases where the customers number many thousands. A great deal depends, however, on the selection of the man for such a post. Anybody will not do. He should


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OFFICE HOURS
BRADFORD CORPORATION
ELECTRICITY DEPT.
ELECTRIC MOTORS, HEATING
AND COOKING APPARATUS
ARC LAMPS &c ON HIRE.

FIG. 40.

be, of course, specially qualified in a technical sense, and also be of an obliging and courteous disposition.

It is advisable that the showroom should be located in a convenient, easily accessible, and, if possible, central position of the town. A shop front, where articles could be exhibited with, say, one or two working models of motors, would possess a double advantage: the premises would be attractive, and their locality would soon become well-known. When a portion of the electricity works or the Town Hall office is set aside for the purpose, much of the usefulness of the showroom will of course be lost. The former is usually too far out of the town for many persons to reach, and the latter is not likely to offer the same attractions to the public as a shop.

The accompanying illustration (Fig. 40) shows one of the front views of the Bradford Corporation's showroom.

In addition to the function which it has just been suggested should be the characteristic feature of the showroom, there are other ends it may well subserve. But the further scope will, of course, depend upon local circumstances, and the extent to which the electricity committee considers it advisable to enlarge their enterprising borders. Where the corporation themselves contract for installation work, or a hiring-out department exists, much of the clerical work can be allocated to the showroom.

The books of these departments, the nature and method of keeping which have been explained in Sections II. and V., should be kept by the showroom staff, which, of course, would have to be augmented for this special and superadded work. In such cases it could be arranged that the payment of small accounts, such as for motor oil, carbon brushes, arc lamp carbons, &c., and the rental for apparatus on hire, should be received at the showroom at the time of making the purchase or applying for goods on hire. This would save considerable time and work, by superseding the usual routine of making out formal accounts which have to be paid at the collector's office at the Town Hall or elsewhere, to say nothing of avoiding bad debts and relieving the

1

Received *189*

from Mr...............................

....

for..............................

....

....

For Electricity Dept.

....

£ s. d.

1

..............................*189*

COAT OF ARMS.

Received *for the*..............................*Corporation*

from Mr...............................

the sum of..................*pounds,*..................*shillings,*

and..................*pence, for*..............................

....

For Electricity Department,

.... STAMP IF REQUIRED. ....

....

FIG. 41.

consumer from much trouble. The form of receipt could be as shown in Fig. 41, and the money paid in daily to the collector's office.

We have thus dealt with the showroom, considered specifically as a general inquiry office; let us now proceed to look at it in the aspect of a showroom, taking the term in its usual significance. The articles on exhibition should include heating and cooking apparatus, of which the radiator (Fig. 42) has hitherto been the most popular; electric motors fitted up in sizes varying from $\frac{1}{2}$ horse-power to 10 horse-power; electric fans and forms of ventilating apparatus; samples of

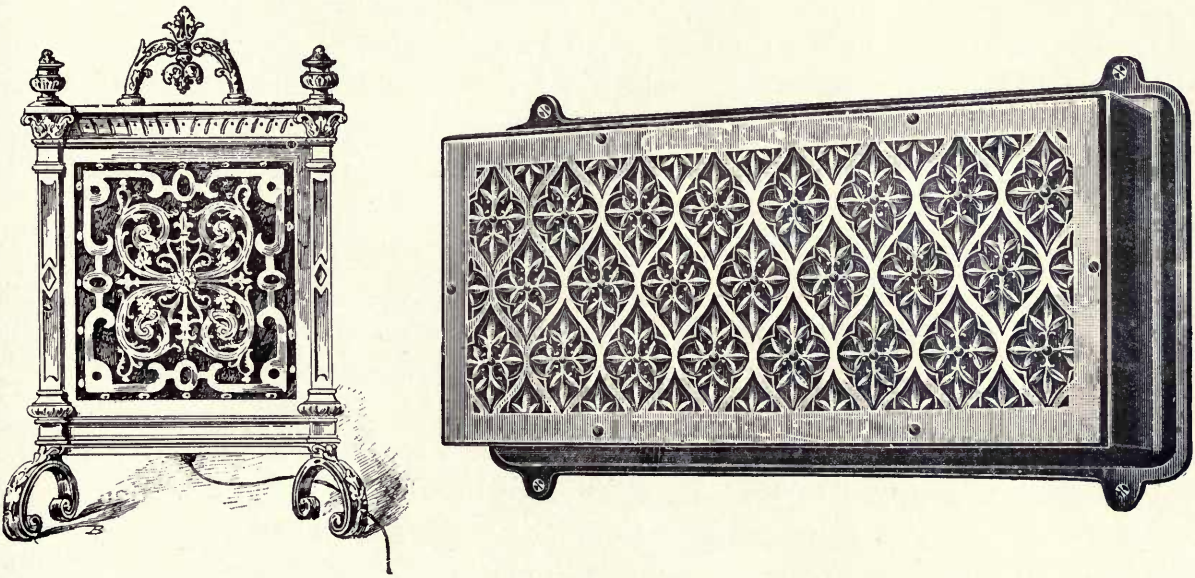

Fig. 42.

material used in wiring work, showing the quality and design required by the corporation; printed matter relating to every branch of the undertaking; apparatus, if any, used in the method of charging for electricity supplied, such as demand indicators, time switches, &c.; types of arc lamps, such as open, enclosed and double-carbon, and incandescent lamps, showing classes of terminals, methods of frosting, and efficiencies of different candle-powers for varying situations.

Some municipalities, who do not care to undertake the sale of goods, enter into an arrangement with different firms to exhibit their goods, referring purchasers to the firms direct, but charging a small commission on transactions. A list is then kept at the showroom, giving prices and approximate current consumption of each article.

It is almost unnecessary to add to what has already been suggested, the necessity of having a supply of electricity for showroom requirements. If the system is low-tension continuous current, with three wires, then the three wires should be brought into the premises. If, however, the system is alternating current, then it will be advisable to keep at hand transformers for varying voltages. Suitable switchboards should be arranged on one or more of the sides of the room, with cut-outs on both poles, and a series of terminals for branch circuits, to be readily connected to any apparatus. Each of these branch circuit terminals should also have double-pole fuses. There should also be ample floor space. Not that a large supply or stock should be stored in these premises. It should not indeed be necessary to keep at the showroom more than a sample or two of each kind of apparatus. Space is a desideratum, rather, because of the necessity which will frequently arise, of setting out individual items of stock for inspection and examination.

Sources of Dissatisfaction.—Considering the imperfections of all human methods and business, it is not to be expected but that some dissatisfaction with the supply of electricity will arise, even in connection with the very best managed undertakings. Causes for complaint, more or less well grounded, are bound to occur from time to time. Nevertheless, they should be few and far between; and, speaking generally, the number and frequency of complaints are a very reliable indication of the sort of management which exists. By the term "management" must be understood not only the responsibilities of the chief engineer, but also the methods of the electricity committee, as it not infrequently happens that trouble and dissatisfaction arise as much through the action of the one as the other. It has already been stated in this Section, that, as far as possible, and at any rate as regards complaints

of a minor sort, they should be made at one department prescribed for the purpose—preferably at the showroom—and should be attended to, in the first place, by one official. His duty would be to take all particulars of the irregularity complained of, to enter the details in a special book kept for the purpose, and to see that immediate and satisfactory attention was given by that particular section of the department which it concerned. Before enumerating the chief causes of dissatisfaction among consumers, we may remark that inattention and "shelving" is in itself a source of serious irritation, and often enough only tends to intensify the original grievance. On the other hand, an endeavour to deal promptly with matters in dispute or under investigation, will help considerably in settling them. There can be no doubt that a promiscuous and indifferent manner of dealing with complaints is not conducive to the best interests of the undertaking. A system in this respect, as in all other departments, is absolutely necessary if the business is to be conducted on lines as near perfection as possible. The "Complaint Book" should show the date a complaint was made, the dates on which it was attended to and remedied respectively, and by whom. These suggestions can, of course, only possibly apply to individual cases. But there are other irregularities which affect the consumers as a whole, and which, perforce, are of a more important character. The following list is a summary of the more general causes of dissatisfaction, viz. :—

1. Fluctuations in the voltage and irregularities of the supply.
2. Breaksdown.
3. Inefficient lamps.
4. Inaccuracy of meters.
5. Charges for service lines.
6. Delays in connecting to supply.
7. Cutting-off supply.
8. Fuse-blowing.
9. Increase of account, compared with gas.
10. Irregularities of arc lamps.
11. Irregularities of motors.
12. Incivility of officials.

We will deal with the foregoing in the order given.

1. There is, of course, an imperative necessity with electricity supply to maintain, as constantly as possible, and within the smallest percentage variation, an uniform voltage over the entire network of the distributing mains. Fluctuations in the voltage, and such irregularities of the supply are, therefore, sources of very considerable annoyance. The pressure should not deviate in any case, and at all conditions of the load, more than 2 per cent. from the normal, and means should be at hand, at the central station, to ascertain and record continuously, the voltage at each of the feeding points. The maximum variation allowed by the Board of Trade is 4 volts, and the clauses in the regulations are as follows :—

(a) "During the whole of the period when a supply of energy is required to be maintained by the undertakers in the distributing mains under the order and these regulations, it shall be maintained at a constant pressure, in these regulations termed the 'standard pressure;' but the standard pressure may be different for different portions of the distributing mains. Provided that the undertakers shall be deemed to have complied with the requirements of this regulation, so long as the pressure does not, at any point, vary more than 2 per cent. from the corresponding standard pressure in the case of a general supply at high pressure, or 3 per cent. in other cases, unless changes in pressure recur so frequently as to cause unsteadiness in the supply."

(b) "The variation of pressure at any consumer's terminals shall not, under any conditions of the supply which the consumer is entitled to receive, exceed 4 per cent. from the declared constant pressure."

From these provisions it will be seen that efficient means must be taken to ensure against both "high" and "low" voltage, in relation to the declared pressure at the consumer's terminals, and hence the necessity to avoid a fall of potential in the distributing mains, as well as to maintain a constant pressure at the feeding centres.

It is not the usual practice at the present time to insert regulating resistances in the feeders of continuous current systems, in order to

maintain an uniform voltage at all the feeding centres. The feeders should be so proportioned to the respective natures of the demands, as to obviate the necessity of such a method. In the case of alternating current systems, the addition of transformers becomes necessary from time to time.

There are other classes of fluctuations, in addition to the deviation from the normal through variations in the load. There is the constant "trembling" vibration in the light, due to bad governing of engines, and which occurs, particularly at the lighter loads, when only one engine is running. It may affect but a few consumers, but it is none the less a defect of the supply, and should be overcome. There is also the peculiarly irritating fluctuation, due to purely local circumstances, such as the starting, stopping, and working of electric motors, or search lights, switching "on" and "off" stage lights in theatres, and similar causes. Such effects should be minimised as far as possible, by making certain forms of motor starters compulsory, and by enforcing the use of special forms of resistances in theatres. Of these three distinct causes of fluctuation in the light, that of low voltage at the time of maximum demand is undoubtedly the most serious, and will cause widespread dissatisfaction and complaint.

2. *Breaksdown.*—Fortunately, it may be said that breaksdown are not so frequent as in the earlier days of electricity. Still, they are all too frequent at the present time, and it is a significant fact that failures are due, in the majority of cases, to defects in the electrical equipment, in contradistinction to the mechanical. This clearly points to the necessity for further improvement in that direction, the principal causes being either the blowing of main fuses through external short-circuits, the unreliability of automatic switches, the "earthing" of alternators, and the explosion of gases in street conduits. It is not proposed here to enlarge upon either of these causes—they are matters for technical investigation and treatment; but there can be very little satisfaction, and no feeling of confidence, where these so-called accidents are of periodical occurrence. The failure of supply means, *pro tem.*, a reign of darkness, and involves

loss of business to consumers, opportunity for robberies and shop-lifting, to say nothing of small inconveniencies. There can be but little wonder, that neither a maximum demand tariff nor cheap installation work, can induce the public to rely solely upon electricity as an illuminant, in the face of experiences of that sort.

3. *Inefficient Lamps.*—For some appropriate remarks on this point, *i.e.*, the dissatisfaction arising through inefficient lamps, the reader is referred to the section on the free supply of incandescent lamps.

4. **Inaccuracy of Meters.*—Much of the trouble which arises through the inaccuracy of meters is undoubtedly due to the want of proper examination, incomplete testing, or unsuitable capacity in relation to the installation. In conveying from the test-room to the premises of the consumer, damage is sometimes done to a meter, whereby its calibration is upset and its starting current raised. With a careful examination and a thoroughly reliable staff, these troubles should not occur.† A certain percentage of meters, however, will always be found defective at the periodical inspection, and occasionally, perhaps, the meter will not be registering. It is usual with some undertakings to make an estimate of consumption in such circumstances, but this is, of course, only a compromise, and has to be done in a very unbiassed and tactful manner. It is indeed far better to sacrifice a few units through non-registration than it is to prejudice the consumer against the meter, and to lose his confidence in it. In the case of complaints of meters reading high, considerable satisfaction will be given and confidence restored, if the consumer is supplied with *data* by which he can himself watch the registration of his meter, without the necessity of removing it to be tested. He should be told, or a printed notice should be attached to the meter card stating, that a 16 candle-power lamp, in use for one hour, consumes ·06 of a unit, or that sixteen 16 candle-power lamps will consume almost exactly (960 watts) one unit in the same time ; and so on, for different candle-power lamps and other apparatus.‡

* See also Section VII., page 150.

† See "The Practical Testing of Electricity Meters for Central Stations," by C. A. L. Prusmann, A.I.E.E., Assistant Electrical Engineer, Bradford, contributed to *The Electrical Engineer*, January 13th, 1899, page 38.

‡ See also Section VII., page 146.

It is not proposed here to deal with those original defects to which the various types of meters are liable. Such defects will be found in the test-room, or in the removal of defective meters from consumers'

TABLE XXIII.

1897. — Months	Number of Meters Tested		Number of Meters sent back to Makers		Number of Meters Accepted		Percentage Rejected	
	Watt	Ampère-Hour	Watt	Ampère-Hour	Watt	Ampère-Hour	Watt %	Ampère-Hour %
January	...	31	...	10	...	21	...	32·3
February ...	12	6	4	2	8	4	33·3	33·3
March	...	38	...	13	...	25	...	34·2
April	...	34	...	14	...	20	...	41·2
May...	18	20	...	8	18	12	...	40·0
June	...	24	...	13	...	11	...	54·2
July...	...	44	...	25	...	19	...	56·8
August	...	42	...	25	...	17	...	59·5
September ...	5	68	...	44	5	24	...	64·7
October	...	60	...	20	...	40	...	33·3
November ...	...	58	...	27	...	31	...	46·6
December ...	...	36	...	18	...	18	...	50·0
Total	35	461	4	219	31	242	11·4	47·5

premises. There are works specially written on the subject. The above Table, No. XXIII., however, will show the number of meters tested by the meter department at Bradford in 1897, and the percentages which had to be sent back to the makers, through defects which existed when making the *first* test after delivery at the works.

Reference has been made to the fact that meters are sometimes placed on circuits where the number of lamps is out of proportion to the capacity of the meters. That is to say, the meters may be either large enough to carry two or three times the number of lights actually in use or installed, or they may be too small, and therefore working overloaded. The first disproportion should not exist to any appreciable extent in an undertaking where there is any approach to systematic and methodical supervision. The second occurs more frequently through consumers extending the original installation, or substituting lamps of higher candle-power than those originally applied for. Such cases can only be met by a good and regular system of inspection, and when a complaint of the meter is made by a consumer, the investigation should include all the points to which reference has just been made.

5. *Charges for Service Mains.*—By the term "service mains" must be understood all branches, from the distributing or street mains, which are necessary for supplying one consumer or a group of consumers. It is clear that a portion of such mains will be upon public property, and a portion on private property. The question which has agitated many municipal electricity committees, is whether the cost of service mains should be charged to the consumer. It is a condition of all Provisional Orders that, wherever distributing mains are laid, service mains shall not be charged for certain distances on public property, unless such service main exceeds that distance. In Bradford the distance is 10 yards, in Hull 30 yards. A municipality is, therefore, entitled to charge for all cables and work done on private property, and for all mains and work done on public property, if the distance exceeds that prescribed by law.

There can be no doubt that, as a matter of policy, it would often be in the interest of the undertaking to waive the charges for service mains on private property. But a difficulty arises in making an arrangement which would be fair to all consumers, and which would not entail any serious loss upon the department. For instance, in the centre of

the town, the amount of cable on private property is not more than a few feet on the average; but in the residential and outlying districts, where there are large gardens, and the houses stand back far from the roadway, the amount of cable on private property is generally several yards in length. In Bradford, it has been attempted to meet the difficulty by waiving the charge, when the amount is under £2. A more serious difficulty, however, is the case of the consumer who is beyond the limit of compulsory supply. There seems to be no alternative but to require that he should pay the cost of laying the necessary service mains over and beyond the compulsory distance. It may, and frequently does happen, that there are other residents intervening, and if these, not requiring the accommodation, should resolutely refuse to bear any proportion of the cost of the service, the expense would be almost prohibitive. Such are very common examples of somewhat difficult problems which electricity committees and engineers are called upon to solve without creating precedents, and yet satisfying the consumer, if possible. Each case must, of course, be considered and dealt with upon its own merits; but one way out of the difficulty is to charge two years' interest and sinking fund on the capital outlay, say 15 to 20 per cent., the electricity department taking the risk after that time, relying, of course, on the probability of other consumers requiring in the meantime a supply from the same service mains.

6. *Delays in Connecting to Supply.*—This is a source of complaint which is often of an irritating character to both parties concerned. Wiring contractors have an unbusinesslike and chronic habit of giving notice to the supply authorities that an installation is ready for testing and connecting, and expecting attention to be given the same moment. As a matter of fact, it is absolutely necessary to require forty-eight hours' notice, in order that proper arrangements may be made for fixing the meter, and testing, &c. It frequently happens, also, that the insulation or other tests are not satisfactory, and the connecting-up has to be postponed, much to the disgust of the consumer, who probably has no other means of adequate illumination. It is always as well, therefore,

in order to obviate these sudden and unreasonable demands, to adopt a definite and systematic course of procedure. The forty-eight hours' notice should be made a *sine qua non* in every case, to be sent in in writing, signed by both the wiring contractor and the consumer, and addressed to the head office.

7. *Cutting-off Supply.*—This procedure is usually and perforce adopted with a consumer, in the event of persistent non-payment of account, or in consequence of some dangerous defect in the installation. It is an option which the supply authorities have in their hands, in order to protect both themselves and the consumer in case of extreme necessity. This, of course, renders it a means of final resource and, therefore, to be used with the utmost discretion, and only in extreme and urgent cases. Nothing is to be more strongly condemned than a practice of cutting-off supply, or even threatening to do so, upon any and every occasion in which the consumer does not happen to comply with all the supply authority's requirements. Like the surgeon's knife, it should be resorted to only when amputation is the one last remedy. To use it as a common resource upon ordinary occasions, is to cause disgust and annoyance, and nothing is more likely to drive people to use private installations. Wherever possible it is advisable to give at least seven days' notice in writing to the consumer, in which to pay arrears or to have a defect remedied, pointing out at the same time that the supply is liable to be cut-off on expiry of the notice, if the conditions are not complied with.

8. *Fuse Blowing.*—While this unpleasant experience in installations is practically an unavoidable contingency, that is to say, while fuses and the use of fuse-wires are compulsory, it will be incumbent upon the electricity department to be prepared to deal with them with the least possible delay. This entails the services of an extra man or extra men, to "stand-by" at the works during hours when the ordinary staff are off duty, in order at once to replace fuses in consumers' premises, whenever and wherever summoned. It will usually be found that fuses "blow" in installations of the cheap and fragile sort, or that the accident

is the result of inexperienced interference by the consumer or his household. A typical instance came under the author's observation recently. A jeweller's assistant found difficulty in making a lamp effect proper connection in a bayonet lamp-holder, and thinking that one of the plunger contacts was sticking, the assistant used a pair of pliers to pull it down. As he had forgotten to turn off the switch, the holder was, of course, immediately short-circuited, blowing the main fuse and burning the man.

Fuse-wires are notably unreliable as regards the fusing point, but at the present time there is no substitute. A more desirable arrangement would be a maximum current automatic cut-out switch, which could be readily replaced by the consumer.

9. *Increase of Account, compared with Previous Gas Accounts.*—This is a somewhat common and regular form of complaint. Strangely enough, however, complainants are quite forgetful of the relative advantages of the two forms of illumination. The increased cost is usually, and very often ignorantly, ascribed to the meter reading high, which, upon test, is probably found not to be the case. As a matter of fact, and as a rule, consumers are not slow in embarking on more electric lights, and those sometimes of a higher candle-power than were previously used with gas. The effect is pleasing and novel, and the lights are kept burning for a much longer time than was hitherto the case. There is, moreover, the practice to put three lights or more on one switch, whereas two gas-lights at the most had originally been found sufficient. Electric light accounts should range, in the majority of cases, from an equal amount to twice the amount of the gas-bill for a corresponding number of lights, according to the average price per unit charged.

It would be as well, therefore, to investigate these cases of increased accounts, when made the subject of complaint, and to point out to the consumer where the difference exists and, if possible, how to economise in the future.

10. *Irregularities of Arc Lamps.*—As a general rule, the ordinary wiring contractor in a town is quite incapable of, nor has he facilities

for, the repair and adjustment of arc lamps. Yet he is often the only individual to whom the consumer can turn to execute the work, and the too frequent result is that the lamps, so far from being improved, had better have been left untouched. The Bradford Corporation have recognised this unsatisfactory condition of things, and have issued the following notice:—

"For the convenience of those consumers on the corporation electricity supply mains, who are users of arc lamps (other than those let out on hire), the committee have arranged to test and regulate these lamps at a fee of 5s. per lamp, payable in advance.

"This charge includes the removal of the lamps to the corporation electricity works, cleaning and regulating, and also the loan of temporary lamps for use by consumers whilst their own lamps are being overhauled.

"The advice of the electrical engineer will be given, should repairs to the lamps be found to be necessary, but the above fee does not include any repairs whatever.

"Prior to the removal of any lamps by the officials of the corporation electricity department for any of the above purposes, the outer globes must be removed by the users of the lamps, and taken charge of by them, as the corporation cannot undertake any responsibility for breakage of globes, there being no necessity to remove the globes (except in the case of enclosed arcs) with the lamps. Consumers must also replace the globes themselves after the lamps have been re-fixed by the corporation officials."

11. **Irregularities of Motors.*—Very little complaint arises in connection with the use of motors. Alternating current motors are troublesome sometimes, but this is a matter for the technical advice of the electrical engineer to the supply authority. Continuous current motors require replacement of brushes and attention to the commutator occasionally. The chief trouble is likely to arise with the motor-starting switches, through sparking and breaking down of the resistance coils. Where a considerable number of motors are on the supply it is highly

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* See also Section V.

advisable to employ a permanent motor inspector to make periodical examinations. He should be in uniform.

12. *Incivility of Officials.*—In no case is it more necessary to employ men discreet in their dealings, and civil in their manner, than in the public service. Incivility and arrogance must not be tolerated for a moment. In private business, such characteristics in the employees would very soon result in serious loss of custom, and no firm would think of retaining their services one moment beyond the legal necessity. Very great importance attaches, therefore, to making close observation of the demeanour of those officials who are daily and hourly brought into contact with the public, and there should be no hesitation in dealing in a summary manner with any gross breach of behaviour.

SECTION XI.

PRIVATE HOUSE CONSUMERS, OR EXTENSIONS TO OUTLYING DISTRICTS.

This subject is becoming of increasing importance day by day, both to the municipal electrical engineer and the municipality, and to each it presents many interesting and many novel features. The extension of electricity supply from the central station to the outlying districts of a township or borough has, however, already become in very many cases a matter of immediate urgency, and while in each case distinctive features and characteristics exist, there are also many points common to all which may be considered with advantage.

The municipal electrical engineer is face to face with the problem of extending the supply in the most economical and satisfactory way; the town councillor has before him the demand for the supply from the members of his constituency in outlying districts. It is therefore proposed to deal with both sides of the question from a general point of view, and the remarks will apply equally to all municipal electric light undertakings, irrespective of the particular system adopted in each borough.

There are, at present,* in operation in England, Scotland, Ireland, and Wales, about seventy-three municipal electric light stations. Of this number, forty have been in operation over three years, and it is generally after the lapse of this period of time that the *necessity* to extend the hitherto confined area begins to be felt.

* March 1899.

Having decided that a necessity will always be sure to arise, *nolens volens*, the points to be considered may be stated to be :—

1. The cost of extending the supply.
2. The effect on the cost of production and revenue.
3. The advisability of extensions.

1. *The Cost of Extending the Supply.*—Priority has been given to this particular phase of the subject as bearing on the whole question, because it is the point upon which, very naturally, great stress is laid by electric light committees. It is often made the most important point, other aspects being considered secondary matters. Unfortunately, too, comparisons are only made with what has been the cost of supply in the central portion of the town. These comparisons, however, are incorrect, and too great prominence is often given to the initial cost of extensions.

The cost of extending the supply is affected by :—

1. The method of laying cables.
2. The characteristics of the suburban or outlying district.
3. The extent and class of demand.

By the method of laying cables must be understood the system which, in economy and efficiency, is found to be most satisfactory when the characteristics of the suburban district in which the cable is to be laid, and the extent and class of the demand, are taken into account. It is, therefore, essentially a question which can only be decided for each district separately by each town individually, considered with reference to the general system of electrical supply adopted by each. But after all this has been said and emphasised, it may also be accepted as true, universally, that many of those items which form so large a proportion of the cost of laying mains in the centre of a town are very much modified, if not entirely eliminated, in connection with the extension of mains in the suburbs. Such items are (1) the reinstatement of footways and road paving; (2) the necessity for making ample provision for future demands by laying additional conduits; (3) the avoidance of obstacles under the footways and roads.

Now it is not necessary to enlarge upon the very different effect which these items have upon the cost of laying the mains in the central and outer districts respectively. One or two illustrations will suffice. The attention of the reader is drawn to them because in some towns the difference will, no doubt, be very much greater than in others. In the matter of reinstatements, the cost of different paving is given in Table XXIV., for towns differing in importance, position, and configuration.

TABLE XXIV.

COST OF REINSTATEMENTS PER YARD RUN.

(About 2 feet wide.)

Town	York Stone, including New Stone	Patent Asphalte	Compo. Stone	Granite Sets and Concrete
City of London ...	3/8	Footway 6/4 Roadway 11/-	...	7/6
Hove (Sussex) ...	1/6	3/6	3/-	...
Hull	2/7	...	...	6/5
Bradford	3/8	...	...	8/4

From Table XXIV., it will be seen that the cost of reinstatements varies considerably; but the figures are also indicative of the width and depth of trench made, and from this it may be inferred that more or less provision had to be made at the time of opening for future extensions. A proportion, therefore, of the cost of reinstatement of conduits and cables laid, really represents capital already spent for an extended supply, and which is lying idle until a revenue is derived from outside.

The method of laying cables in the central area is very naturally determined by the conditions referred to above; but where such conditions do not exist, as in the outer districts, other methods of laying

mains may be adopted, by which the cost may be still further reduced, when compared with that involved by the original method.

We now come to the characteristics of the outlying districts, and the probable extent and class of demand, considered in relation to the cost of extending the mains. These two items are taken together, as the one depends very largely upon the other. In the very broadest sense these, of course, are really the determining factors with regard to the size and length of mains to be laid down. It is here explained how this may be ascertained as a very much more definite quantity than is possible when estimating the probable demand in the central area. The outlying districts may be scattered or thinly populated, or they may be the reverse. There are usually both instances in most towns. In the first case, such districts are likely to be composed of large houses, rich residential neighbourhoods, and unpaved streets; in the second case, we may assume that main streets leave the town, with a continuous run on each side of terrace houses, occasional shops, with a surrounding neighbourhood of side streets and residences.

Now the very first advantage we have in considering the possibilities of supply in the above cases, and the consequent size of cables ultimately required, is the fact, that while on the one hand the probable demand required for business purposes is a greatly varying quantity, and one utterly impossible to forecast; on the other hand, in residential quarters, it may be comparatively easily gauged. For instance, some shops in the centre of a town have been known to be let and re-let in the course of two or three years; one tenant requiring eight or ten lights, another requiring no light at all, and a third demanding a supply for forty or fifty. This is only a typical instance of what occurs over and over again. Under such circumstances there is no basis upon which to work, and hence we have to be prepared for any demand. But it is different with residential houses. The annual rental is a safe guide, as Table XXV. of rentals and corresponding gas bills, real and not imaginative, will show. The gas is 2s. 3d. per 1,000 cubic feet, and the length of the street it about three-quarters of a mile.

Each single account represented in the above summary showed, upon comparison, very little variation from one year to another, and, therefore, it should not be a difficult matter to estimate the maximum number of electric lamps likely to be required for many years in such a

TABLE XXV.

Description of Property	Annual Rental	Number of Houses, Shops, &c.	Aggregate Amount of Annual Gas Bills	Average Annual Amount per House, &c.
	£ £		£ s. d.	£ s. d.
Shops only...	20 to 40	19	76 3 0	4 0 0
	40 " 50	2	11 18 0	5 19 0
	50 " 100	6	58 19 4	9 16 6
Houses only	20 " 40	24	91 8 4	3 16 2
	40 " 50	19	147 16 2	7 15 7
	50 " 100	50	506 0 2	10 2 4
	100 " 150	2	27 18 10	13 19 5
Houses and Shops combined	20 " 40	11	49 9 2	2 4 11
	40 " 50	17	146 1 4	8 11 10
	50 " 100	20	243 7 0	12 3 4
	100 " 150	4	92 16 10	23 4 2
Hotels	100 " 350	3	233 10 6	77 16 10
Theatres	1000	1	333 14 8	333 14 8

district. The table, of course, represents only one main street, but the illustration will serve for any branch streets and abutting property. Hence we can see how the characteristics and probable demand enable us to make accurate calculations, and so economise in the method of laying and the capacity of the mains.

Now it will readily be admitted that the points just dealt with are the very points which form the basis of comparison in estimating the relative value of one system over another. But, whatever the system, there can be no doubt that the cost of extending the mains can be very considerably reduced when compared with the cost of laying mains in the centre of the town.

2. *The Effects on the Cost of Production and on the Revenue.*— Supplying outlying districts with electricity would appear, at first sight, simply to entail increasing the output at the central station, with a corresponding increase in the revenue, and the cost of production would appear to be affected just in the same way as if the additional supply occurred in the central portion of the town. In reality, however, the effect on the cost and revenue is of a much more important nature, and it is this feature which gives the supply a relatively higher value. This is due entirely to the fact that the number of units consumed for a given maximum demand is very much greater in the outlying districts than for a corresponding demand in the centre of the town. In other words, private houses, small shops, &c., use the light for a greater number of hours than business offices and large shops within the central area. While the latter use a large number of lamps for a few hours a day, the former use only a few lamps but burn them a considerable time. And so it comes about that the number of lamps installed cannot be made a direct and all-sufficient basis of calculation in estimating the probable revenue. We must also take into consideration the number of hours the lamps burn. Very considerable assistance may be obtained in arriving at an approximately correct estimate if we know what is the general figure in lamp hours per day in several towns. In the following towns the number of units sold per average 8 candle-power lamp connected are approximately as follows :—

Town	Units sold per lamp
Hull	11·23
Aberdeen	12·85
Hanley	16·80

Town	Units sold per lamp
Leicester	17·46
Blackpool	18·05
Bradford	18·68
Manchester	20·60
Bristol	22·02

If we take these figures and reduce them to the number of hours per day during which the total number of lamps would be burning in

TABLE XXVI.

Town	Watts per 8 c.p. lamp per day	Average hours per day per 8 c.p. lamp would be burning
Hull	30	1 hour, 0 minutes
Aberdeen	35	1 ,, 10 ,,
Hanley	46	1 ,, 32 ,,
Leicester	48	1 ,, 36 ,,
Blackpool	49	1 ,, 38 ,,
Bradford	51	1 ,, 42 ,,
Manchester	56	1 ,, 52 ,,
Bristol	60	2 ,, 0 ,,

order to produce the above annual output in units, we get the result in Table XXVI.

The average of these representative figures is 1 hour, 33 minutes; or, in other words, the total capacity of the station is being used for only

1 hour, 33 minutes per day, in producing the very satisfactory results to which these towns have attained. There can be no question that the time during which the major portion of the revenue is earned is for the first two or three hours after dusk. A reference to any central station load curve will prove this, and further, more than 50 per cent. of the lamps connected are not in use at all for six months of the year. Now this is just where the private consumer comes in and fills the gap. His lamps, although adding to the plant capacity at the station, also increase the average earning capacity, and in the proportion estimated in the following hypothetical case :—

If we assume that an equal supply is demanded by the central and the outer districts respectively, then, of course, the plant capacity at the station would be double that required for the central portion only, and if the class of demand was like that in the central area, the whole plant would still be earning its entire revenue in 1½ hours per day. But we may safely assume that 75 per cent. of the demand in the outlying districts will be continued from 7 to 11 p.m. on an average throughout the year, or, we will say, for fully four hours longer than the central portion. Now 75 per cent. or half the maximum demand, is equivalent to a little above one-third of the maximum demand continued fully for four hours, and this is, of course, equal to the full demand continuing for one hour and three-quarters. It will at once be seen from this simplification of the matter that the earning capacity of the plant has been increased from 1 hour, 33 minutes, to 3 hours, 18 minutes, or more than two-fold ; or, in other words, the number of units sold are doubled for the same maximum demand. But what is true of the whole is true of a part, and hence the earning value of every 8 candle-power lamp connected in the outlying districts, is three times as great as that of the average burner in the central portion of the town. In addition to this relatively higher value of the residential supply as compared with the shop and office supply, the former would be required very largely on Sundays, thus giving an additional 52 days' consumption on the year. It would also form a better load on

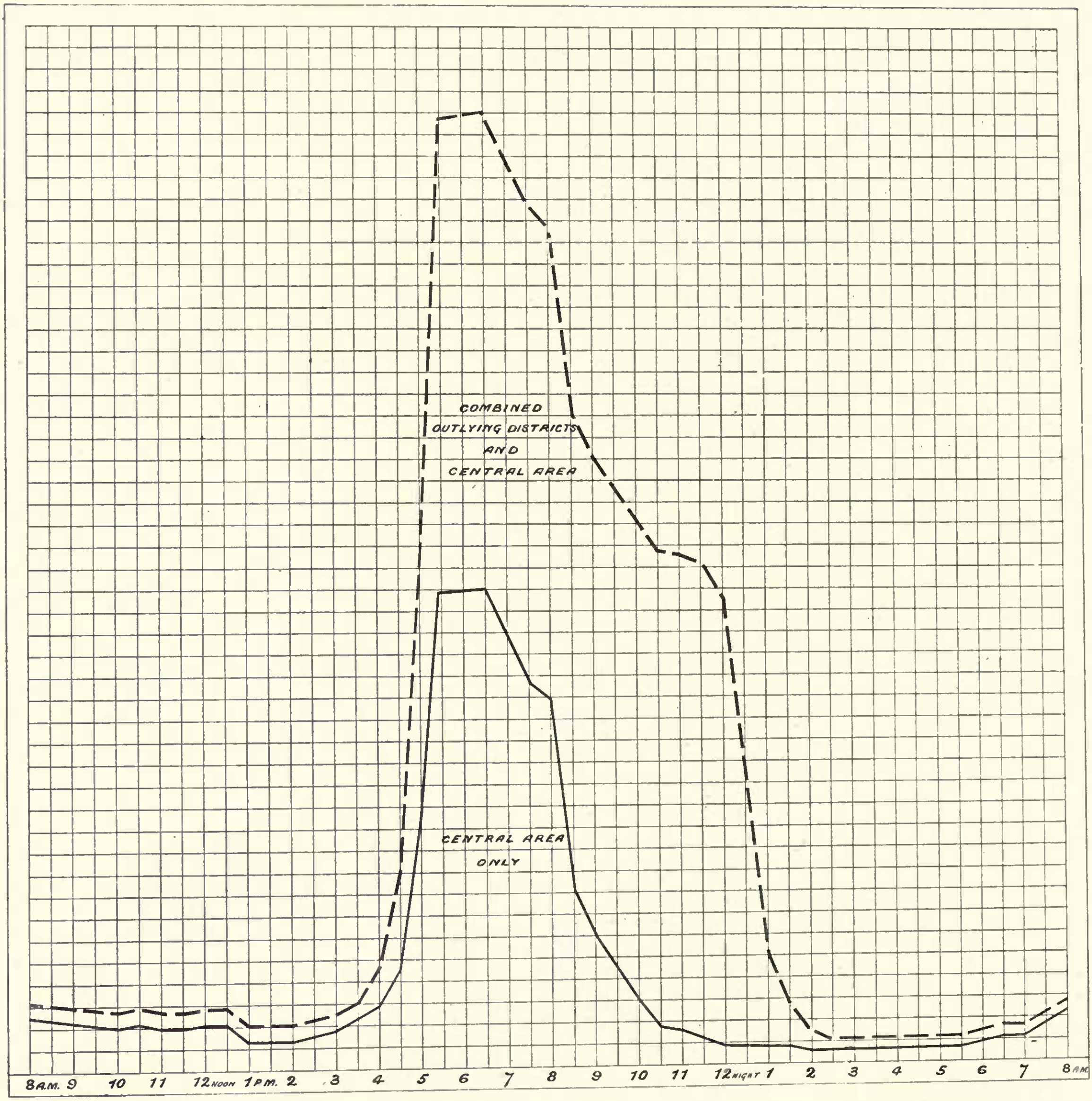
COMBINED
OUTLYING DISTRICTS
AND
CENTRAL AREA
CENTRAL AREA
ONLY
8 A.M. 9 10 11 12 NOON 1 P.M. 2 3 4 5 6 7 8 9 10 11 12 NIGHT 1 2 3 4 5 6 7 8 A.M.

FIG. 43.

holidays, and during the winter from 6 a.m. to 8 a.m. For all these reasons, such a supply is eminently desirable. Fig. 43, taking the hypothetical case just given, represents the ratio of the one supply to the other.

Having determined the relative value of the demand from residential districts, it is but an easy step to ascertain the effect on the cost of production and on the revenue. The cost of production is made up of the actual cost of generation, viz., coals, oil, &c., and the standing charges, viz., wages, salaries, repairs and maintenance, interest on capital, sinking fund, depreciation, rent, rates, taxes, &c. Taking the average of a score of central stations we find the charge per unit to be about as follows :—

Generating cost	1·0d.
Standing charges...	3·5d.
Total	**4·5d.**

With a slightly increased efficiency of the generating plant, that portion of the cost is likely to be slightly reduced ; but we will nevertheless take it to remain practically the same per unit, viz., 1d. But, assuming an equal demand in both central and outlying districts, the number of units sold for the same standing charges is doubled, and, therefore, this item of the cost would decrease in the same ratio, that is to say, the 3·5d. per unit would become 1·75d., and the total cost per unit 2·75d. instead of 4·5d. This at once opens up the possibility of a substantial reduction in the price ; a reduced price would probably attract new customers, and thus, step by step, we might ultimately arrive at an universal adoption of the light. We can even imagine the demand from the outlying districts being twice as much as that in the central area (a very common feature of gas supply), and, in that case, a general price of 3d. per unit would then be most remunerative. This, at least, seems to be certain, that every lamp connected in the residential districts has the effect of helping to reduce the standing charges in the ratio of 2:1, as far as its own consumption is concerned.

With the foregoing explanation it is easy to see what is the effect on the revenue. The price to the consumer remaining the same, 5d., 6d., or 7d., the revenue or *net profit* would be increased by exactly the same amount as the standing charges would be decreased. In the example given the standing charges would be decreased by 1·75d. per unit, and by itself this amount would form a very considerable net profit, even if the average charge per unit was only $4\frac{1}{2}$d. The average price obtained, however, by most municipalities is more than $4\frac{1}{2}$d., and at that price a net profit is made of from 3 per cent. to 5 per cent. Of course, the object of the municipalisation of these undertakings is to supply electricity at as reasonable a price per unit as is consistent with fairly paying expenses and providing for contingencies, but the price will never descend to a popular figure while the supply is confined to the central area. The possibility of a reduction commences, however, as soon as the many-hours private householder has the opportunity of using the light. Such a reduction should take place naturally and gradually as the demand in the outer districts increases, and when we remember that every lamp supplied there brings in the same revenue as three in the central portion, the effect on the profits of the department would not be long in becoming appreciably apparent.

3. *The Advisability of Extensions.*—In dealing with this question, reference is made more particularly to what may be termed commercial enterprise. An endeavour has been made to show that as a question of finance such extensions would probably be very remunerative, but there is, of course, still another factor to be taken into consideration, and that is the rate at which consumers will avail themselves of the new light in these districts. But the same uncertainty existed not so many years ago when the public supply of electricity from a central station was first commenced. At that time, too, there were many other problematical features which do not exist to-day; there were obstacles, prejudices, conflicting interests, which have since been overcome, and the responsibility of such an enterprise as a wholly new undertaking was, beyond

all comparison, greater than any question which electric lighting committees are now called upon to consider.

Then the venture was almost entirely speculative, owing to the absence of fundamental data, and, in many instances (notably Bradford, the first municipal central station supply), the business was started to keep out a private company. The success which has been met with, however, has been beyond expectation, and this fact is in clear evidence by the present corporation electricity supply undertakings, and by the efforts of several other municipalities to buy up the rights which they have so recently allowed to fall into the hands of private companies. These rights and undertakings will undoubtedly have to be paid for very heavily before the corporations become possessed of them.

Yet in the face of these practical experiences we still hear of towns and parishes who are fighting the same old battles and traversing the same dreary ground about the establishment of electricity works as were settled by the pioneer municipalities many years ago.

We might reasonably infer from what has been the experience in regard to the central area, viz., that while it was difficult to forecast the probable demand, yet the result has been a very general adoption of the electric light, so with regard to the outlying districts, the result should be an equally steady increasing demand. As to the probability of this deduction being verified an instance is here given in point. In 1893 the Bradford Electricity Committee canvassed, among other districts, the street referred to on page 219, and for which is given in Table XXV., the representative annual gas bills.

This canvass was a personal house to house enquiry, but not a single individual would give a guarantee to take a supply. In June 1894, the committee made a further effort by means of a circular letter. Very few replied, and only one individual definitely promised his patronage. At the beginning of 1896 the question again came before the attention of the committee; and they were advised to lay the mains as a matter of speculation, and they so far conceded as to grant the extension for three-quarters of a mile. Of course in face of what may be called the

negative results of the canvass this was a great and bold step to take. When this was known to the wiring firms, they, on their own account, immediately canvassed the street, but in one month, only succeeded in getting three applications, with a total of seventy 8 candle-power lamps. A month later the laying of the mains was commenced, the wiring firms in the meantime continuing to solicit orders, but without success, the general excuse being a desire to wait until the mains were laid. So the mains were started with three promised consumers. Before the entire length was laid, however, the number had increased to ten, demanding a maximum supply of 210-8 candle-power lamps, and, as an instance of what a little judicious speculation will do, the number of consumers at the end of 1898, or less than three years after the mains had been completed, was 95 with 4,694-8 candle-power lamps connected. Now this instance is a very good argument against relying to any extent upon canvassing. Of course the streets with which to commence the extension have to be selected with discretion, but once started a supply will soon be demanded over the entire area of the borough.

To sum up the whole matter. It appears that at the present time, the great object for municipalities to aim at is the reduction of the price at which electricity can be supplied. We contend, and have endeavoured in this section to justify the contention, that this object is attainable. Not only so, but that it may be attained in a most satisfactory manner by developing the enterprise. Like the railway companies of old, we should go *forward*, certainly not in a headlong spirit of reckless extension, but, on the other hand, with an unhesitating and deliberate movement of advance.

SECTION XII.

SUNDRIES.

The numerous and varied applications of electricity referred to in this section have been grouped together because, in the first place, some of them are of such a nature that the cases in which they can be supplied from the electricity mains of a corporation are few, and in the second place, some are in an experimental stage only. Developments in every direction of applied electrical science are taking place day by day, and some are on the very threshold of great and important commercial possibilities. It is as well, therefore, for municipalities to keep up with the times in these matters for, as has been already stated in a previous section, local conditions are often particularly favourable to the adoption, even in an experimental sense, of one or another of them. The estimates and figures given in the following descriptions, are either taken from statements of manufacturers or are the results obtained from actual operation.

Electrical Heating and Cooking Apparatus.—This class of apparatus is now made by several firms in the United Kingdom, in America, and on the Continent. A list may be found in any electrical directory. There are probably three main reasons why electrical heating and cooking apparatus has not been more extensively adopted. First, the apparatus itself is expensive to manufacture, and hence costly to purchase ; secondly, the transformation of electrical energy into useful heat is of very low efficiency ; and thirdly, in so many cities and towns the price per unit

for electrical energy for these purposes has hitherto been kept abnormally high. The initial cost and the price of supply, however, are being gradually reduced, the list given in Table XXVII. being a fair example of the present cost and expense of working various appliances.

It is not proposed here to enter into any elaborate description of this class of apparatus. Each manufacturer usually issues very complete and descriptive catalogues, from which such information as is required can be obtained, and wherein all the advantages of the use of the apparatus are set out. There are also one or two special treatises on the subject.* It will be seen that most of the apparatus in Table XXVII. is small and of a portable nature, and therefore may be found exceedingly convenient, notwithstanding the expensiveness of the current. With regard to the heating of public halls or theatres by electricity, very little has been done, for the cost, owing to the great space to be heated, would be prohibitive. One instance, however, can be given, viz., that of the Vaudeville Theatre in the Strand, London, which has been heated throughout by Crompton radiators for more than five years. A considerable number of radiators are used in theatres, however, to warm dressing-rooms, green-rooms, &c., the Savoy Theatre, Strand, London, having several.

In calculating the amount of electric power required for heating a room, it is usual to assume 500 watts to the 1,000 cubic feet, and that this power will be required for about two hours during the coldest days of the winter, and about one-third of the power for the remainder of the day.

There are one or two special trade purposes to which electric heating is peculiarly adapted. One of the applications is in connection with the account-book binding trade,† in which hot plates are used for heating small tools used in gilt lettering; glue-pots for binding purposes, taking about three ampères apiece; wax pots for sealing purposes; and

* "Practical Hints on the Use of Electrical Cooking Apparatus and Instructions for Using Electric Heating Appliances," by Mrs. Seaton. Crompton and Co., Chelmsford.

"Electric Heating," by Prof. E. I. Houston and A. E. Kennelly cloth, 4s. 6d. Published by Electrician Printing and Publishing Co., London, E.C.

† See "Electric Heating," *Lightning*, November 17th, 1898.

TABLE XXVII.

Article	Price	Volts	Ampères	B. T. Units per hour
	£ s. d.			
Ovens	10 0 0 and upwards	115	26 downwards Regulated by switches	3·00
Breakfast cooker	5 10 0	„	8·0	·92
Grill, nickel-plated	1 15 0	„	3·5	·40
Frypan	1 12 6	„	4·0	·46
Hot plates	1 1 0 and upwards	„	2·5 upwards	·28
Hot cupboard...	10 0 0 „	„	20 Regulated by switches	2·30
Saucepan	1 12 6 and £1 15 0	„	10 to 15	1·30
Stewpan	2 2 0	„	3·5	·40
Kettles, copper and brass (2 pint)	1 10 0	„	4·5	·51
Kettles, ornamental silver-plated	5 0 0	„	4·5	·51
Water boiler...	1 5 0	„	1·8	·20
Egg boiler	2 2 0	„	1·8	·20
Urns	3 10 0 and upwards	„	4·5	·51
Bronchitis kettle, copper ...	1 12 6	„	2·5	·28
Steriliser, nickel-plated copper ...	6 0 0	„	5·0	·57
Radiators, plain screen	2 10 0 to £7 10 0	„	2·6	·29
Radiators, ornamental screen ...	3 0 0 and upwards	„	2·6	·29
Ship radiators	2 5 0 and upwards	115	3·5	·40
Wall radiators	3 0 0 „	„	5·3	·60
Foot warmers	1 10 0	„	1·75	·20
Flat iron	1 7 6 to £1 15 0	„	3·0	·34
Tailors' goose iron	1 12 6	„	3·5	·40
Billiard table iron	3 0 0	„	3·5	·40
Hat iron, nickel-plated	1 10 0	„	1·75	·20
Curling irons heater (single) ...	1 7 6	„	1·75	·20
Goffering irons heater (triple)...	3 3 0	„	5·25	·60
Sealing wax heater	2 2 0	„	1·75	·20
Cigar lighter	2 2 0	„	·06	·06
Shaving pot...	1 5 0 and £1 10 0	„	1·75	·20

ovens and plates for heating the backs of books, the risk of burning, which occurs when heated over gas, being thus avoided, while an uniform temperature is ensured.

Another trade electrical process is the Sarfert system of electrical pressing, in which advantage is taken of the ability to maintain an uniform temperature for any desired length of time. It is claimed that many disadvantages inseparable from the present methods of hot pressing in the dyeing and finishing trade, are entirely overcome, and that the process is much cheaper. The present methods consist of heating separate iron plates in an oven, and of heating hollow iron plates by steam. These it is proposed to replace by "electric plates," to which the current can be switched on at will. This process is said to be more cleanly in its operation; there is less heat in the factory, and greater economy is effected. At the same time, there is less liability to damage the goods to be pressed, and a better "finish" into the bargain. The cost of working the apparatus is also said to be small. To heat a hydraulic press charged with heavy goods to a height of two-and-a-half yards, with seventy electrically heated plates, in thirty-five minutes, costs 0·11d. per plate, at one penny per Board of Trade unit, or 8d. for the whole press.

Electricity for this and similar processes, in which the voltage necessary is likely to vary, and which is usually required lower than the voltages for electric lighting, can be supplied from public mains through motor-generators or transformers, with but little loss in the transformation.

There are many other useful industrial applications of electric heating, such as medical cauterisers, steel tempering, softening hardened plate steel in the places required for rivet holes, scientific instrument making, and applications to special technical trade purposes.

Electric Welding.—The application of electricity to welding metals has met with great success in the United States, and is being gradually adopted in the United Kingdom. In Glasgow, an electric welding plant is in operation, for joining the ends of two steel wires which are inserted in a solid rubber tyre, and both wires are welded in the one operation.

The electric current is supplied from the city mains through a motor-generator. Several steel pipe and tube makers in Birmingham, Sheffield, and elsewhere, also employ electricity for welding on flanges, &c.

One of the methods employed in the art of electric welding, is that of causing currents of electricity to pass through the abutting ends of the pieces of metal which are to be welded, thereby generating heat at the point of contact, which also becomes the point of greatest resistance, while at the same time mechanical pressure is applied to force the parts together.* As the current heats the metal at the junction to the welding temperature, the pressure follows up the softening surface until a complete union or weld is effected; and, as the heat is first developed in the interior of the parts to be welded, the interior of the joint is as efficiently united as the visible exterior.

Some of the advantages of electric welding are as follows :—

1. The homogeneous nature of the weld. When the weld is made, the structure of the metal at the joint is the same as elsewhere.

2. Absolute control over the heat. By simple appliances, the metal can be held at any desired temperature for any length of time, or increased or decreased at will.

3. The welding process can be continually watched. The metal, while being heated, is visible, instead of being covered, as in the forge process.

4. Avoiding flaws.

5. Rapidity. The process is almost instantaneous with small diameters.

6. Flexibility. Various kinds and forms of metal can be welded, including those which have hitherto been united only by brazing.

7. Accuracy. The welds can be kept in perfect line.

8. Localisation of heat at the weld.

9. Cleanliness and avoidance of dirt.

10. No blistering, scaling, or other injury.

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* Process of Thomson Electric Welding Co., Lynn, Massachusetts, U.S.A.

See also "Electric Heating," by Prof. E. I. Houston and A. E. Kennelly; published by the Electrician Printing and Publishing Co., London, E.C.

11. Simple and easy in operation.

12. Economy in labour, time, and material.

An illustration of these welders is shown in Fig. 44, and they are in use by The Telegraph Construction and Maintenance Co., Messrs. Siemens Brothers & Co., Messrs. Callender & Co., The Whitecross Co., and others; and these firms have found them to be of great commercial value.

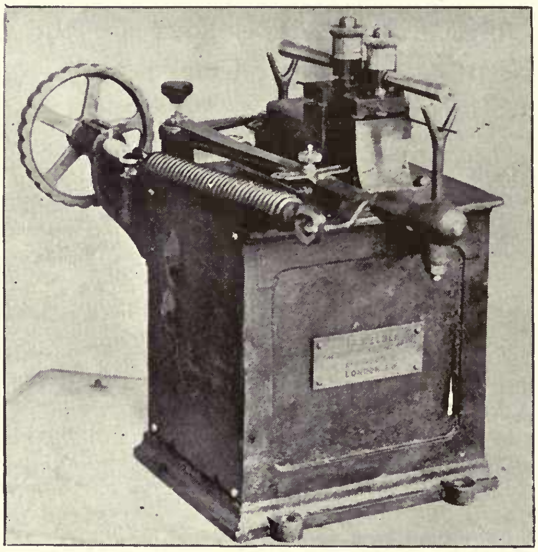

Fig. 44.

The following is a description of the apparatus :—

The wire welder consists of one special transformer, composed of laminated iron core, with highly insulated primary coil, to stand the 300 volts primary pressure.

The secondary winding consists of solid copper casting, equal to one turn in which the primary coil is embedded. The whole of the transformer, with the exception of the ends of the secondary, is enclosed in a substantial iron case.

The ends of the secondary circuit are provided with very substantial adjustable *clamping devices*, for gripping the various sizes of wire during welding. One clamp is firmly fixed to the cast-iron box, and the second clamp has a movable device, to enable it to move towards the fixed clamp in the operation of welding. Both clamps are suitably insulated with red fibre insulation from the cast-iron box. The upper part of both clamps is fitted with suitable adjustable clamping devices with removable steel cheek pieces, the bottom part (copper) in like manner being fitted with removable cheek pieces, so that different sizes of wire may be securely clamped.

An automatic switch is provided on the wire welding transformer, with marked quadrant and set screw, which enables the exact length of upset on the weld to be adjusted. The movable clamp is attached by means of a lever to a strong steel spiral spring, which is provided with a suitable means of adjustment to enable the tension, *i.e.*, the pressure on the moving jaw, to be varied, and the variation can be properly adjusted by means of graduated scale.

The transformers are intended to be worked off a constantly excited 300 volt circuit, at fifty complete periods per second, and have a welding capacity for continuously welding No. 2 S.W.G. iron wire, or No. 6 S.W.G. copper wire, of suitable quality.

Three gauges for setting the jaws of the transformer for different sizes of wire are provided, and one special spiral spring for small wires.

The power required varies nearly as the sectional area of the material at the joint where the weld is to be made. Table XXVIII. gives the power and the time required for various sizes of round iron or steel and iron piping.

Alternating currents are most suitable in the Thomson process for electric welding purposes, where the alternations per second are between forty and eighty. Energy can be supplied from the ordinary lighting mains for small welding machines ; the larger sizes are likely to cause considerable fluctuation on the lights in the vicinity. With continuous current systems of supply, motor-transformers must be employed.

Another system of welding by means of electricity is known as the Bernados system. This process is in extensive use at the works of Messrs. Lloyd & Lloyd, Birmingham, who were the first to make it practically possible ; at Messrs. John Brown & Co.'s works, Sheffield ; by the Leeds Forge Co. ; and by Messrs. John Spencer & Co., Wednesbury, &c.

The distinctive feature of this process is that the welding is effected by means of the electric arc, formed by bringing a carbon

TABLE XXVIII.

Round Iron or Steel			Iron or Steel Pipe		
Diameter in Inches	Watts	Time in Seconds	Inside Diameter in Inches	Watts	Time in Seconds
$\frac{1}{4}$	1,500	10	$\frac{1}{2}$	6,700	33
$\frac{3}{8}$	2,500	15	$\frac{3}{4}$	7,800	40
$\frac{1}{2}$	4,800	20	1	12,250	47
$\frac{5}{8}$	6,700	25	2	31,350	84
$\frac{3}{4}$	10,000	30	3	72,000	106

rod, which makes one terminal of the system, to the work to be welded, and to which the other terminal is connected. This system has some advantages over the Thomson process, according to the nature of the weld required. It is, moreover, a method in which the continuous current is necessary, and it cannot be satisfactorily operated without a battery of accumulators.

The current required will, of course, vary considerably, but the voltage should not be less than 150, which can be reduced to the exact pressure required by means of regulating connections from the accumulators.

Electro-Plating.—This industrial operation, for which, through the agency of the motor-generator, power can be supplied from either the alternating or continuous current systems of supply, is carried on in almost every town. The nature of the requirements in the form of a supply of electricity, is necessarily small in quantity, but of long and continuous duration. Therefore the supply is in the nature of a day load.

Motor-generators for this purpose cost from £10 to £50, and are much more economical than batteries. The voltage required varies from two volts to 100 volts, according to the nature of the work and the method of coupling the depositing vats or tanks. Full information can be obtained from special works on the subject.*

In connection with electro-plating, it is necessary to use polishing machines which revolve at several thousands of revolutions per minute, and which can most conveniently be driven from an electric motor. Instead, therefore, of using a motor-generator, it may be found most desirable, everything considered, to employ an electric motor of sufficient power to drive the electro-plating dynamo, the polishing machine, and any other apparatus which may be required in the business.

The following businesses will be found to use electro-plating processes or appliances:—Ironmongers, for kitchen utensils, cheap silver and nickel-plating, burnishing and polishing, silversmiths, goldsmiths, electrotype block makers for printing, bicycle spoke makers, type founders, brass finishers, cutlers, typewriting machine makers, scientific instrument makers, makers of electric bells, telephones, &c.

Charging Stations for Electric Motor Cars, Electric Cabs, Launches, &c.—There can be no question as to the extensive adoption of electric motor cars and cabs in the immediate future. In many of the important

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* "The Electro-Plater's Handbook," by G. E. Bonney; published by Whittaker & Co., London, E.C.

"The Electrolytic Separation of Metals," by Dr. G. Gore published by The Electrician Printing and Publishing Co., London, E.C.

towns they have already been in use for a considerable time, and to no inconsiderable extent, and there is reason to think that they would in many cases be employed by tradesmen in place of the horse, if facilities were offered by electrical supply undertakings for the proper charging and treatment of the storage cells.

The accumulator, it is admitted, is the great drawback. In its present form the storage capacity, compared to the weight, is altogether out of proportion, and it is otherwise expensive in repairs and maintenance. But many of the inherent defects of the accumulator are rapidly being overcome, and we may shortly expect to see very great improvements made. Even now, however, with all existing defects and drawbacks, accumulators are largely used for motor-car work. The London Electrical Cab Company have about thirty electric cabs in daily use on the streets of London. These have been running for about eighteen months, and the company have now decided to place forty more cabs on the streets. In a report on these cabs, the Commissioner of Metropolitan Police says:—"The hackney carriages propelled by electricity which have been placed on the streets, appear to have given general satisfaction. The vehicles are roomy, the interiors well fitted, and the mechanism is well under the control of the driver. Should electrical carriages come generally into use, the effect on the traffic of the Metropolis will be marked, as such vehicles occupy but a little over half the space as that of a similar vehicle drawn by one horse. From a sanitary point of view, also, the diminution in the number of horses in the streets is a desideratum."

A company has also been formed in Paris on almost identical lines with those of the London Company, but they are putting on the streets no less than 100 of these vehicles.

There are also several privately owned electric cabs, broughams, and other vehicles in other parts of the country, and these are used where there are private electric generating plants.* The electrically-

* All types of Electrically-propelled Vehicles are made by The Britannia Motor Co., London, and The Pope Manufacturing Co., Hartford, Conn., U.S.A.

propelled carriage has many advantages over those driven by petroleum or spirit. There is no irritating vibration due to high-speed reciprocating engines, nor is it necessary to keep the motor running while the vehicle is at rest. It is more cleanly, and the repairs and maintenance of the accumulators should not be more than with oil engines.

The more extensive adoption of electric auto-cars will rest very largely with the municipalities. It is, of course, impossible to use electricity as a motive power where there are no means, or rather facilities, for charging the accumulators. Accumulators for motor car use cannot be removed from the car and conveyed to an electric light works every time they require re-charging. What is undoubtedly required, and that immediately, is the establishment of "charging" depôts in various parts of each town, at which any electric vehicle can be re-charged at a quick rate, and for a reasonable price. It is useless to wait until electric propulsion has become a necessity. The "charging" depôts must be established first of all. Such depôts would only require very simple and easily managed apparatus. A motor-generator, and a series of terminals for connecting the accumulator "leads," are necessary, together with facilities for regulating the voltage. The London Electric Cab Company commence the charging of their accumulators at 90 volts, and finish at 112 volts. The full rate of charge for each battery is 30 ampères, but in allowing for cells that are partially sulphated, and which require to be charged at a lower rate, it is necessary that the charging should continue for about nine hours.

Each cab is capable of running from twenty-five to thirty-five miles with one charge, depending upon the state of the roads it has to travel over.

The Production of Ozone.—This gas, which is nothing more or less than condensed oxygen, is produced by electro-static discharge. The apparatus for its production is now made on a large scale for commercial purposes,* and thus with cheap generation there are a great many uses to which it is applicable. Electric ozonising apparatus of any size

* The Electric Ozone Syndicate, Ltd., 5 New Union Street, Moorgate Street, London, E.C.

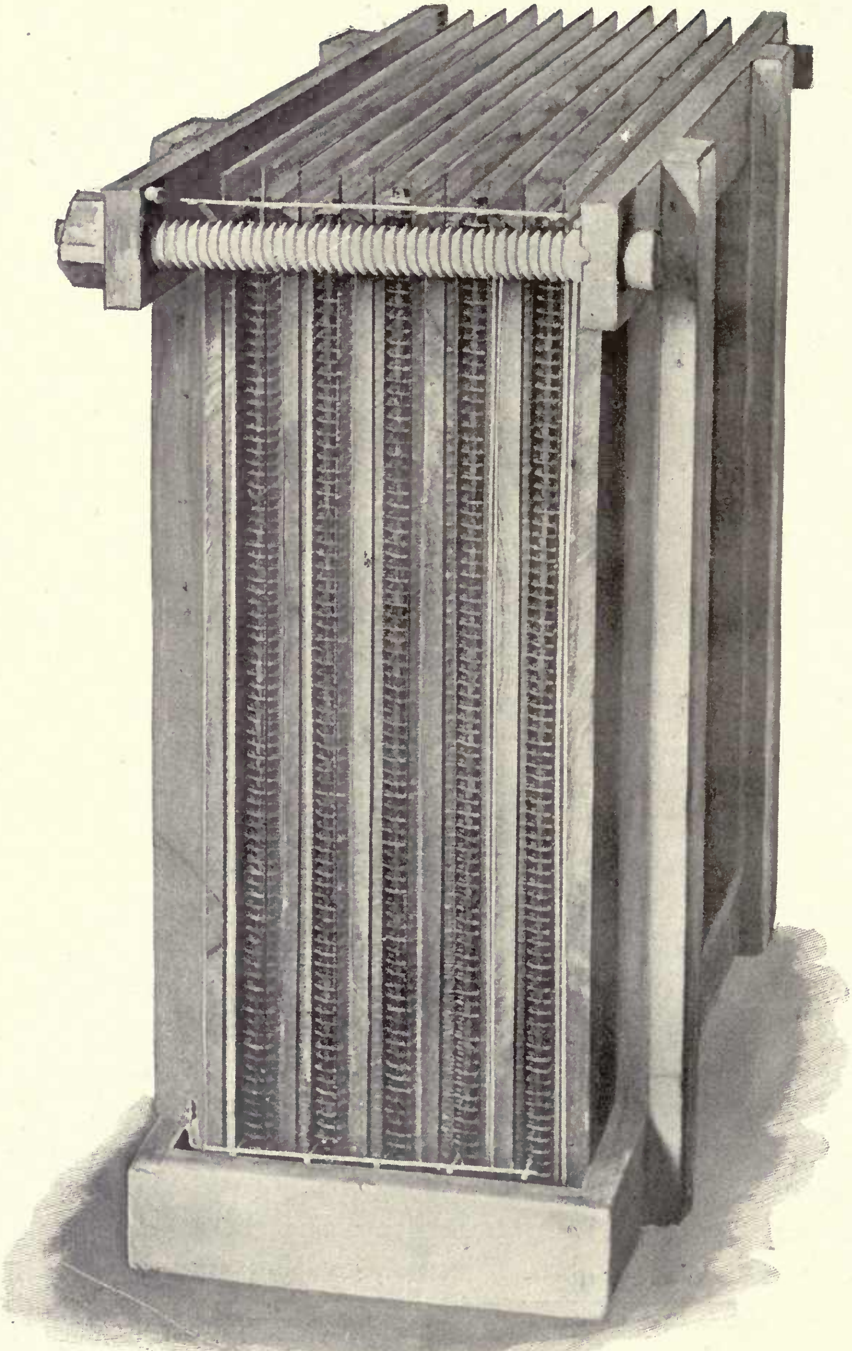


FIG. 45.

or description, can be supplied with electricity from electric light street mains, the voltage required varying according to the size of the ozone battery. With the alternate current system of supply only a step-up transformer will be necessary, but with the continuous current system there will, of course, have to be provided a motor-generator and a transformer. For the production of small and insignificant quantities of ozone, primary or secondary batteries will be found sufficient.

An illustration of a commercial form of ozoniser, with 80 square feet of electrodes is given in Fig. 45. It is stated that the most advantageous conditions for obtaining a good yield of ozone, and at the same time for safely working the ozone generators during a long run, are fulfilled when the current absorbed for the electrification does not exceed 0·75 watt per square foot of electrode. At this rate 60 watts are required per set of 80 square feet electrodes. It is not advisable to consume as much as 1 watt per square foot: so high a power would soon lessen the efficiency of the apparatus.

When the atmospheric air traverses this element or unit at a certain speed, and with a current of 0·75 watt per square foot, the yield is from 7 to 8 grammes of ozone per hour. It therefore follows that with five, ten, or fifteen times this amount of electrical energy, distributed between five, ten, or fifteen such units or more, the yield of ozone will be five, ten, or fifteen times greater, and so on.

With 20 grammes of ozone, according to Dr. Fröhlich, of Messrs. Siemens and Halske, of Berlin, it is possible to bleach in one hour 110 pounds of linen as well as would be done by grass bleaching in three days. It will, in presence of chlorine, also bleach and refine 88 pounds of potato starch to such a degree that the colour becomes a clear white, and the bad odour and taste are removed; the same quantity of ozone will ozonise a room containing 8,000 cubic metres, in such a way that healthy persons can only just endure it.

We will now consider the application of ozone to medical and sanitary purposes, which are as follows:—

1. Disinfection.

2. Treatment of wounds and ulcers.
3. Treatment of tuberculosis.
4. Maturing and improving wines and spirits
5. Sterilising foul casks, vats, &c.
6. Oxidation of oils.
7. Seasoning wood.
8. Manufacture of artificial perfumes.
9. Vinegar making.
10. Spent oil making.
11. Bleaching wax, fats, &c.
12. Purification of fish oils.
13. Bleaching.
14. Starch extraction.
15. Deodorisation of cocoanut oil.
16. Sterilisation of impure water.

1. *Disinfection.*—There is an universal consensus of opinion among specialists in sanitary matters on the purification of air by ozone. The following statement by B. W. Richardson, M.D., out of hundreds which might be quoted, is significant :—

"I put," says he, "dead birds and pieces of animal substances, that had undergone extreme decomposition, into atmospheres containing ozone, and observed the rapidity with which the products of decomposition were neutralised and rendered harmless. I employed ozone medicinally, by having it inhaled by persons who were suffering from fœtor of the breath, and with remarkable success, and I began to employ it ever since (viz., since 37 years) for purposes of disinfection in close rooms, closets, and the like.

"I should have used it much more largely, but for one circumstance, viz., the almost impracticable difficulty of making it with sufficient ease, and in sufficient quantities, to meet the necessities of sanitary practice."

2. *Treatment of Wounds and Ulcers.*—The treatment of ulcers, wounds, &c., by oxygen or by ozone, is not at all a new discovery. Years ago oxygen was applied by surgeons to healing ulcerated, mucous,

or suppurating parts of the human body. One of the most striking phenomena is the removal of pain during the treatment.

3. *Treatment of Tuberculosis.*—Ozone has been used most beneficially in cases of tuberculosis.*

4. *Maturing and Improving Wines and Spirits.*—"The beneficial action of ozone on wines and spirits is undeniable. New wines and newly-distilled spirits contain organic acids, volatile oil, and other impurities, which, beside their unpleasant smell and taste, have injurious properties. Raw spirits, or new wines, after a few hours' ozonisation and a rest of a few weeks in a cask, are purified, matured, and improved. All impurities, which occasion the hot fiery taste and unpleasant smell, are eliminated, and the same mellowness, flavour, and bouquet is imparted to them as if they had been kept in the cellar during several years."†

It is indispensable to take into account the nature of the wines to be treated. Ozonised dry and light wines show little alteration, but sweet and heavy wines and liquors are remarkably transformed. Port wine shows the effect of ozonising most rapidly. At the end of two or three days a deposit is formed, and goes on increasing until a very clear wine is obtained, which has an appearance it would only have after remaining in bottle for a long time.

5. *Sterilising Foul Casks, Vats, &c.*—There is at present a great difficulty, almost an impossibility, in cleansing and disinfecting the casks, *i.e.*, destroying the germs and ferments. A comparatively small ozoniser (say one kilowatt apparatus), with the proper appliances for forcing the ozone into the pores of the mouldy wood, ought to be added in every brewery to the cooperage, and it would be a great saving of money. The ozonisers can be worked by any man of ordinary intelligence and skill, and the cost of ozonisation of 100 casks per day would be trifling.

6. *Oxidation of Oils.*—The oil trade, and the manufacturers of linoleum, oilcloth, and varnishes, will find in ozone the oxidiser they require.

* "Researches on Tuberculosis," by A. Ransome, M.D., F.R.S.; published by Smith, Elder & Co., London, 1898. (See page 76.)

† *The British Medical Journal*, July 1890

7. *Seasoning Wood.*—It is preferable to ozonise wood for making musical instruments, and for cabinet and carriage makers, instead of drying it by the traditional method, which consists in keeping it for a long time in sheds.

8. *Manufacture of Artificial Perfumes.*—The following is an extract from the inaugural address, delivered January 13th, 1898, by J. W. Swan, F.R.S., President of the Institution of Electrical Engineers :—"I must not omit to mention a quite different order of electro-chemical effects, in which alternating or intermittent currents of high tension are employed to induce the formation of ozone. By means of ozone, secondary chemical effects of great value are obtained ; among these I may mention the manufacture of vanillin and heliotropine, now established manufactures."

9. *Vinegar Making.*—If instead of blowing air through the alcoholic wort, manufacturers use diluted ozonised air, the formation of vinegar will be facilitated and accelerated.

10. *Spent Oil.*—It is not generally known that ozone can be utilised for making "dégras," *i.e.*, spent oil, which is an indispensable substance in the leather industry. Oxidised fish-oil, mixed or not with animal oils, gives an artificial "article" which is cheaper than genuine "dégras," and possesses all its properties. For "dégras," as for most other applications of ozone, it is not enough to force it into the substance to be oxidised : there are conditions to be fulfilled which the manufacturers only know, and there is a limit to oxidation which must not be overstepped.

11. *Bleaching Wax, Fats, &c.*—Beeswax and other waxes, as well as palm oil, tallow, greases, common fats, &c., are rapidly decolorised by ozone. Some become as white as snow.

Dark fats are generally bleached by chemicals, and the current processes are based on the use of permanganate, bichromate, &c., to *which acids are added.*

It is most advantageous to avoid the use of acid ; by doing so the bleaching can be effected in a more perfect and simple manner, which does not affect the molecular constitution of fats.

12. *Fish Oils.*—Fish oils are purified and deodorised by ozone without the use of any chemicals. They are also thickened.

13. *Bleaching.*—Ozone will play an important *rôle* in the bleaching of textiles and tissues. Its decolorising properties are only available, however, when it is combined, as Schönbein said, with chlorine or other chemicals.

There are, in Germany, two factories where Messrs. Siemens and Halske three or four years ago have introduced ozone. In one of them they bleach linen, cloth, and yarns, and in the other, starch and other amylaceous products are bleached and refined. At Greifenberg (Silesia), fabrics and yarns are bleached; the starch works are at Kyritz, but ozone is not employed singly.

Ozonised oxygen may possibly be used in bleaching paper pulp.

14. *Starch and Dextrine.*—Dr. Fröhlich, of the firm of Siemens and Halske, has devoted a considerable time to the researches and applications of ozone. Refined starch, soluble starch, dextrine, leiogum are extracted from potato starch, but generally in quite an imperfect manner. The ozone process has so much improved them that it opens a new and very profitable field and demand for applications.

"This ozone process consists essentially in purifying starch, and removing its brown colour, bad smell, and taste.

"Refined and soluble starch can be used in a more diluted mass than ordinary starch. Starch for stiffening linen, dextrine, and leiogum, are used by dyers, calico printers, manufacturers of size, and for the manufacture of envelopes."

15. *Deodorisation of Cocoanut Oil.*—Cocoanut oil becomes rapidly rancid, and acquires a sharp odour, an acrid taste, and an almost repulsive smell which is very difficult to remove; it can be disinfected at a low cost by ozone, in combination or not with chemicals. Thus ozone will be of service to the soap trade. The peculiar odour of the oil disappears also under the influence of ozone.

16. *Sterilisation of Impure Water.*—The two most energetic transmitters of diseases are the air we breathe and the water we drink.

Most of the infectious diseases, such as dysentery, typhoid fever, malaria, cholera, enteric fever, &c., are due to the drinking of impure water which may contain the ova of animalculæ, or larvæ and pathogenic germs. Water is an universal carrier of matters, either in suspension, or in solution, or of organic or organised substances, and thus is the greatest propagator of epidemics.

As long as the yield of ozone obtainable per horse-power hour did not exceed 20, 25, and 30 grammes, and the apparatuses were not absolutely capable of working in a continuous manner without breaking down, or getting out of order, it would have been unreasonable to speak of utilising ozone for the purification of water.

To-day, however, we must alter our mind on this subject, and admit that ozone can, even on a very large scale, purify, deodorise, and sterilise impure water, and render it wholesome and drinkable.

When impure water has been subjected to a current of ozone, and has been thoroughly in contact with it, all the oxidisable matter, the micro-organisms, fungi, and living organisms which it previously contained, disappear, and the water is practically and really purified, disinfected, and sterilised.

There is no question of imparting a smell of ozone to water, or of impregnating it with ozone ; the instability of ozone is such that, after a very short time, no trace of it can be detected in the water.

The action of ozone on decaying matters, organic substances, and microbes, is scientifically recognised. Infectious and dangerous bodies are rendered innocuous by the action of ozone.

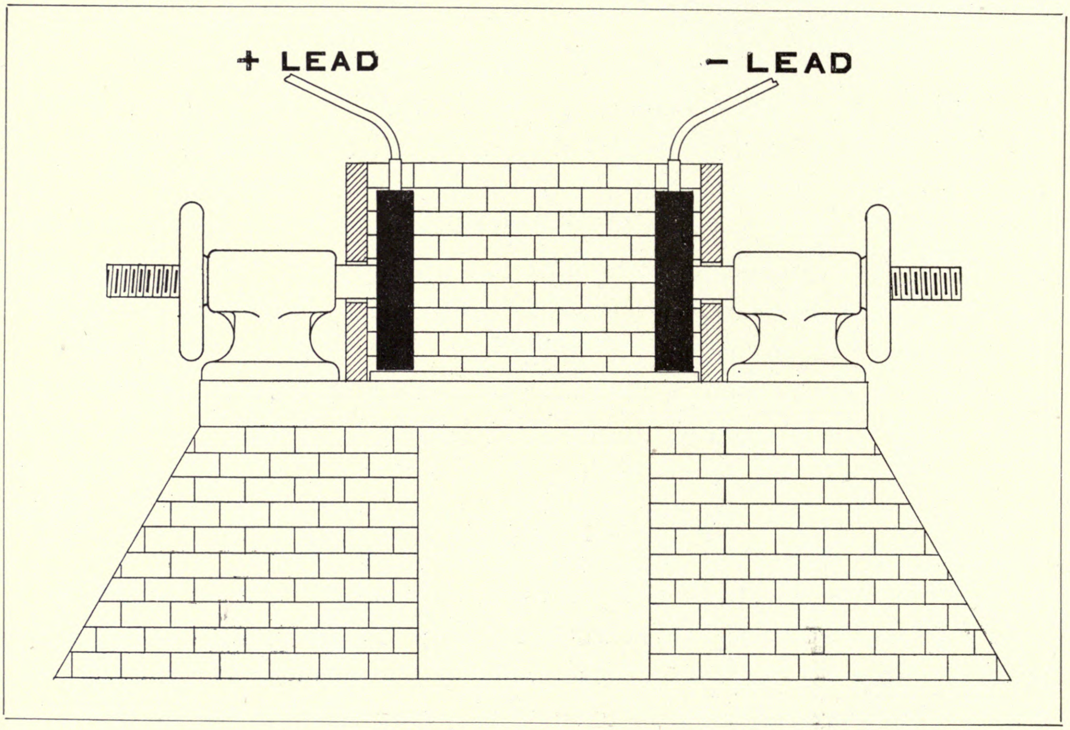
There cannot be any doubt as to the disinfecting and sterilising properties of ozonised air when brought into intimate contact with water. The solution of the problem of the purification of water is in *its ozonisation*, and now that commercial ozone generators, which work in a continuous manner, and yield a sufficient quantity of ozone, are at our disposal, we must begin to consider how this great electric feat of the end of the century is to be planned and carried out.

The Manufacture of Carbide of Calcium.—The recent discovery of carbide of calcium, from which, by the mere application of water, acetylene gas is given off, adds another product of electro-chemistry to the already important list. The introduction of the subject here, and the consideration of the other electro-chemical processes which follow on, is justified by the possibility of such manufactures being carried on with electric energy supplied from corporation electricity mains. At the present time, much yet remains to be accomplished in perfecting these processes, in order to cheapen the cost of production, and to make these commodities of greater commercial utility. But it will be of advantage to consider, even now, to what extent they are commercially dealt with, and to give a brief *resumé* of the processes of manufacture.

Calcium carbide was originally produced as a slag or bye-product of the electric furnace, in its application to the reduction of refractory materials. The bye-product has now become the principal product, and the process is an exceedingly simple one. There are, however, certain difficulties in connection with the construction of the furnace, for the removal of which several patents have been taken out. The materials used are carbon and lime, both of which are of insignificant cost in comparison with the resultant carbide. An illustration of the furnace is shown in Fig. 46.

From this illustration, it will be seen that the furnace consists essentially of two blocks of carbon forming the electrodes inside a fire-brick chamber. These electrodes gradually burn away with the intense heat, and so screwed rods are connected to them, to bring them closer together if required. Between the electrodes the mixed carbon and lime is placed, and the current switched on. By present processes, a power of 300 electrical horse-power at the terminals of the furnace is required to produce one ton of calcium carbide in twelve hours. The present wholesale price of commercially pure carbide of calcium is £20 per ton. One pound will yield five cubic feet of acetylene gas, costing 2·14d., or at the rate of £1 15s. 8d. per 1,000 cubic feet. This appears absolutely prohibitive when compared with ordinary coal gas at, say, 3s.

per 1,000 cubic feet. It must be remembered, however, that acetylene has twenty times the illuminating power of coal gas, and hence one-twentieth of the volume of acetylene gives an equal light. From this particular example, therefore, it will be seen that acetylene gas will give more than one-and-a-half times the illumination of coal gas for the same cost.



Electric Furnace.

Fig. 46.

The generation of acetylene gas from the crystals of calcium carbide, by their immersion in or contact with cold water, is one of the simplest processes that can be imagined. But there is not the same simplicity in storing the gas as with coal gas, and this is one of the

complex and difficult problems in connection with its commercial application. Already a great many inventions for generating and storing acetylene safely are on the market, an illustration of one of which is shown in Fig. 47.

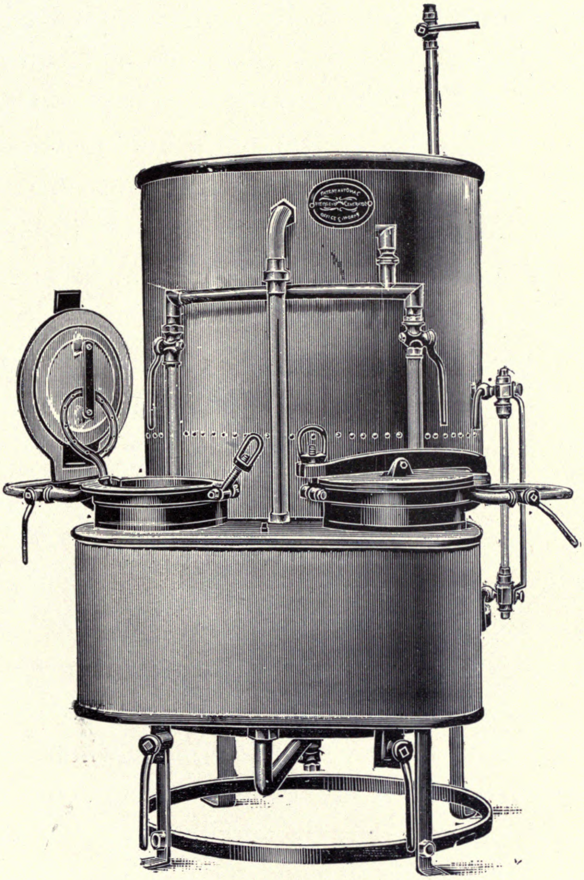


Fig. 47.

Acetylene is difficult of safe storage, owing to its explosiveness at high pressure, which might rapidly be brought about in a gasometer, so readily is the gas given off. Its generation and storage, therefore, have

so far been confined to portable apparatus, and its application to small isolated installations.* It is, therefore, not likely to come into competition with the electric light, as it cannot be supplied to the public from a central gas works, nor has it any of the characteristic advantages of the electric light. The manufacture of the carbide of calcium, however, necessitating the employment of electricity to the extent of many hundreds of horse-power, should become one of the many commercial enterprises which provide a day-load for the central station machinery.

Acetylene gas has many advantages, and some disadvantages, as compared with coal gas. Some of the advantages are :—

1. It gives twenty times the illumination for the same volume.

2. It can be generated in an exceptionally ready and simple manner, at any place most convenient for its use.

3. The rays of the light are a near approach to sunlight, and hence the colours of objects appear the same in both cases.

4. It does not contain any carbonic oxide. Coal gas contains a large percentage of it, and it is the presence of this gas which renders ordinary gas lighting so unhealthy for individuals in confined places.

5. It consumes less oxygen when burnt than coal gas.

6. It heats the atmosphere much less than coal gas.

The disadvantages are principally those which have already been stated, viz., that it is difficult to store it in any considerable volume, and that considerable deposits occur at the burners when pure acetylene is used. These defects, however, are being gradually overcome, and even at present it has been very largely adopted in this country. There is consequently an ever-increasing demand for calcium carbide. The voltage required with the methods at present in use is from fifty to sixty volts, and the current from 1,000 to 5,000 ampères, according to the output of carbide per day.

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* See also Prof. Vivian B. Lewes on "Acetylene;" lectures delivered at the London Institute, November 25th, 1897, Society of Arts, November 1898.

See also *Journal of Acetylene Gas Lighting;* Surrey Street, Strand, London, W.C.

"Lighting by Acetylene, &c.," by W. E. Gibbs; published by Crosby, Lockwood and Son.

*The Manufacture of Carborundum.**—Carborundum is now extensively used in place of emery and corundum for abrasive purposes, such as grinding, boring, shaping, &c. Its chemical nomenclature is carbide of silicon, and it is formed electrically, in the shape of crystals. It was originally and is now extensively made by the Carborundum Company, at Niagara Falls, Ontario.

The crude materials for the manufacture of carborundum are sand, coke, sawdust, and salt. The coke is reduced to kernels of a certain size to be used as "core," and ground to a fine powder to be used in making the mixture or charge for the furnaces. The furnaces are built of brick, and have the form of an oblong box, the internal dimensions being approximately 12 feet in length, 3 feet in width, and 3 feet in depth. The ends are built up very solidly with a thickness of about 1½ feet. In the centre of either end are the terminals, consisting of sixteen carbon rods, 20 inches long and 3 inches in diameter. The outer ends of the carbons are closed in a square iron frame. Finally, all the space between the inside of the plate and the ends of the carbons is tightly packed with graphite. Each plate is provided with a projection, to which the cables conveying the current may be bolted. These ends are the only permanent parts of the furnace. After the circuit has been closed in the transformer room, no apparent change occurs in the furnace for about half an hour. Then a peculiar odour is perceived, due to escaping gases, and when a lighted match is held near the furnace walls, the gas ignites with a slight explosion. When the current has been on for three or four hours, the side walls and top of the furnace are completely enveloped by blue flame of carbon monoxide. During the run of a single furnace, 5½ tons of this gas are given off. At the end of four or five hours the top of the furnace begins to subside gradually, fissures form along the surface, from which pour out the yellow vapours of sodium. At the end of about twenty-four hours the current is cut off from the furnace, and it is allowed to cool for a few hours. Then the side walls are taken down and the unchanged mixture

* See also *Cassier's Magazine*, vol. IX., page 387.

raked off the top of the furnace, until the outer crust of amorphous carborundum is reached. This crust is cut through with large steel bars, and can then be easily removed from the inner crust of amorphous carborundum. The inner crust is next removed with a spade, and the crystalline carborundum exposed.

The crystals are of all colours, red, green, blue, yellow, and violet. The majority of them are small, and they are subsequently ground down to powder. Then they are placed in long tanks filled with dilute sulphuric acid, which removes all impurities and washes them thoroughly. After that, they are sifted and stored away in bins, ready for use.

Carborundum is sold in various forms, such as wheels, hones, files, rubstones, knife-sharpeners, scythe-sharpeners, slips, and cloth. To make up these various forms the powder is mixed with a binding material, moulded, placed in hydraulic presses, and afterwards vitrified in kilns. At first, the largest trade in carborundum was with dentists, who, at an early date, recognised its great value. Now, however, it is seen that carborundum is far superior to emery, in that it will do work quicker and better than that material, saving both time and labour. This is one of the principal reasons why the Carborundum Company was forced to set up a plant on a large scale at Niagara Falls. Carborundum is produced there at the rate of about two tons per day, and even this will hardly be sufficient, so that probably before long, the 1,000 horse-power at present being used, will be added to. The current now required is about 4,000 ampères, at a potential of 150-200 volts.

Electric Timber Seasoning and Preservation.—The difficulty of economically seasoning and preserving timber has now been solved, in a thorough satisfactory manner, by the application of the *Nodon-Bretonneau* process.

The process involves :—

1. The total expulsion of the sap.

2. The replacement of the sap by a *solid matter*, which is *insoluble and aseptic*, thus rendering the wood imputrescible.

The wood is placed flat in a vat containing a lukewarm solution, which solution covers the timber to within a distance of about two inches from the top, at the commencement of the operation, and is gradually lowered towards completion of the process.

Figs. 48 and 49 show a general view and section respectively of this vat.

An electric current under the necessary difference of potential (about 110 volts) crosses the thickness of the wood, entering from the lower part, which is connected to the positive pole, and coming through the top, which is connected to the negative pole of the dynamo. By the action of the current the solution is sucked from the bottom to the top and permeates the whole mass of wood by electro-capillary attraction.

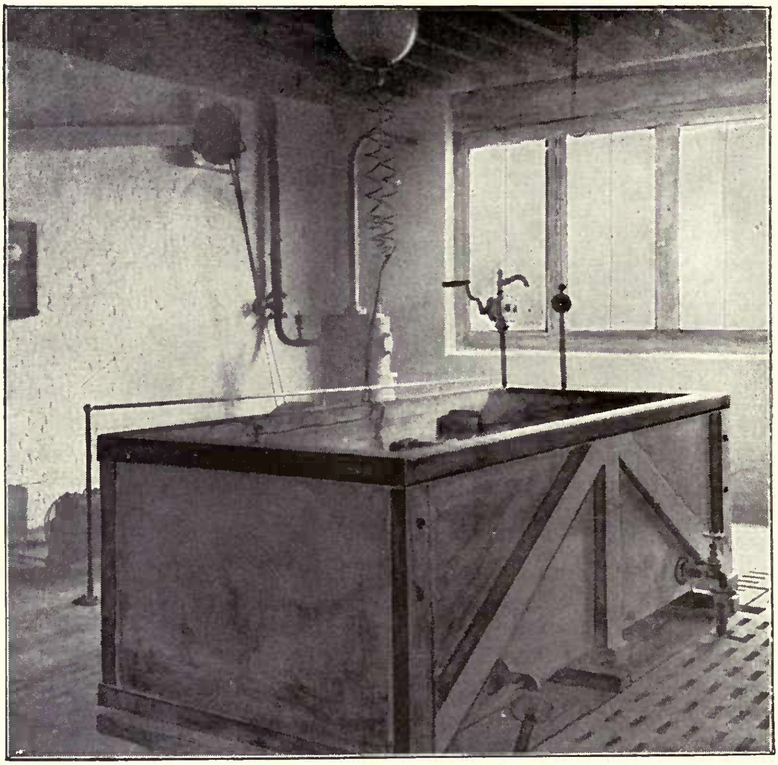
The displaced sap rises to the surface of the bath during the operation, which lasts from five to eight hours, according to the nature and state of the wood under treatment. The solution used for the simple process of seasoning and preserving the wood is a composition called "Bororesinate de Soude," the rosin of which seals the fibres of the wood after cooling, and the boric acid acts as an antiseptic.

The duration of the process is very variable, according to the nature of the wood, its thickness, the season of the year, &c., but it may be taken as varying from between two weeks to two months.

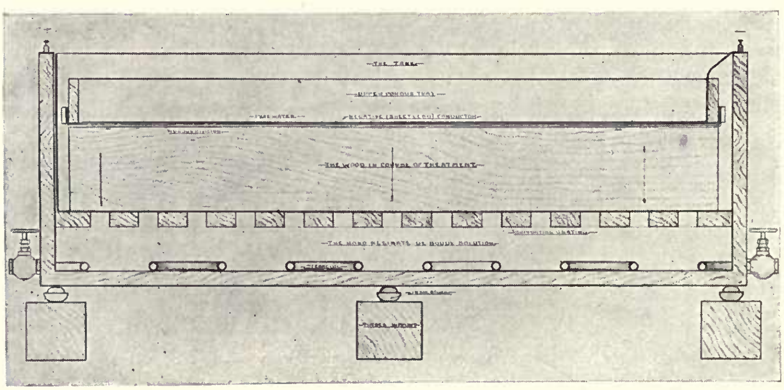
The sap (the cause of all the perturbation) being replaced by a solid and insoluble matter, no longer works in the heat, and having become refractory to the absorption of water, does not swell during damp weather.

The treatment is doubly aseptic by the disappearance of the sap and its replacement by dead matter. It thus prevents the wood from being attacked by chemical agents, by insects, and by animalculæ which produce mould and rot.

Licences are being granted to timber merchants, builders, ship-builders, furniture and pianoforte manufacturers, &c., for the erection of suitable plant within their own premises for the treatment of timber obtained from their regular sources of supply, an invaluable desideratum



General View of Electric Timber Seasoning Vat.
Fig. 48.



Section of Electric Timber Seasoning Vat.
Fig. 49.

to average firms. These licences are subject to the payment of a fixed sum for the plant and annual royalties proportionate to the quantity of timber treated, which is ascertained by a meter registering the watts of electricity consumed.

Applications for licences should be addressed, The Secretary, Electric Timber Seasoning and Preservation Company, 159 Victoria Street, Westminster.

Other Electro-Chemical Processes.—1. *Disinfecting Sewage.*—Sewage has been disinfected and treated by subjecting it to an electric current. It is claimed that by this process, the solid matter is separated from the rest of the effluent and the germs destroyed. Experiments have been made in Manchester and elsewhere, but up to the present, this treatment has proved too costly in its operation.

2. *Hermite Bleaching Process.*—This process requires 1,000 ampères, at 4 volts for each electrolyser.

3. *Tanning of Hides.*—The process of tanning is greatly accelerated by passing electricity through the liquid, and at the same time agitating it.

4. *The Decomposition of Alumina*, for the production of aluminium, requires 14,300 ampères, at 5 volts, for an output of 1 ton per twenty-four hours.

5. *Potassium Chlorate.*—This process requires 1,220 ampères, at 5 volts, for a production of 1 hundredweight in twenty-four hours.

6. *Soda and Bleach*, by the Hargreave-Bird process at Widnes, requires 2,300 ampères, at 4½ volts, for a production of 395 pounds of bleach (37 per cent. available chlorine), and 587 pounds of soda crystals. The time requisite for the process is not obtainable.

7. *Sodium Hypochloride* requires 27 ampères, at 23 volts for a production of 1 hundredweight in twenty-four hours.

Electric Clocks and Municipal Time Service.—Among the many undertakings which, in the public interest, municipalities should conduct, there is none more needed, and none should be more satisfactory, than a public "time" service. With respect to the supply of electricity, gas, water, telephones, &c., it is obvious that a municipality can provide

not only an essentially better, but also a cheaper article, than if each individual householder attempted to supply his own wants. It must have occurred to many persons that clocks should come under this same category; that is to say, that the supply of a correct "time" service would be beneficial to the community, and remunerative as an undertaking, for a municipality. In the first place it may be observed that irregularities in time-keeping are almost as numerous as the sundry household and public clocks themselves, as they now exist. No two of them will be found to agree absolutely. But we may go a deal further than this, for it may be affirmed that absolute accuracy of time-keeping is practically impossible of attainment in any mechanism. Even the most accurate clocks in the observatories, which have carefully compensated pendulums, will get some seconds away from time if left alone for any considerable period. We are, therefore, forced to the conclusion that mere improvement in the clocks generally used could not, from the nature of the case, prove a satisfactory solution of this question. It is, in fact, necessary to strike at the root of the whole matter, the independence of the clocks. The only possible means, in fact, of ensuring accurate time-keeping is by some universal method of regulation, centrally controlled, and supplied in much the same way as the supply of electricity, gas, water, &c.

The methods which have been suggested to accomplish this very desirable object are enumerated below.

1. Electro-magnetic attachments to the lower ends of the pendulums of two or more clocks, causing them to swing beat for beat together.

2. Synchronising the hands of a number of clocks, every hour or once in twelve hours. This is usually accomplished by an electro-magnetic clip which pulls the minute hand forward if slow, and backward if fast.

3. Dispensing with the pendulums, escapements, and mainsprings of a number of clocks, and propelling their wheels forward half-a-minute or a minute at a time by pneumatic or electro-magnetic power, controlled by a central clock.

So many different systems on the lines briefly classified above have been tried that, in reviewing them at this date, we have the advantage of speaking from the practical standpoint of what has succeeded, and not merely from the theoretical view as to what ought to succeed.

Of these three methods, the first—the work of Bain, Jones, Ritchie, Wheatstone, &c.—survives in the form of the Ritchie pendulum, as used in many observatories. It is useful for the accurate synchronisation of a limited number of clocks, but it is found unsuitable in practice for the dissemination of time in a wholesale and economical manner.

In the second instance, the "correcting" or synchronising method (the work of Lund and others) survives in the service of the Standard Time Company, Ltd., who send out hourly signals to correct the hands of a number of clocks in London. The economy of this system, however, requiring, as it does, a special wire and a complete clock at every point, is not remarkable, and on theoretical grounds alone, it is obviously inefficient to retain complete sets of clockworks (which require winding), and to add to them a service wire of which so little use is made.

The third method is undoubtedly the most satisfactory, inasmuch as it is the one which is the nearest approach to the true idea of invention. Inventors often get entangled in the meshes of the mechanism they laboriously seek to simplify; they forget that mechanism is only a means to an end, and that they ought rather *to do without it altogether.* This has been lamentably apparent in the field of electric clocks, where so much time and money has been wasted on clocks which will go backwards (the pendulum revolving the wheels, instead of the wheels swinging the pendulum), and clocks which "will go without being wound up."

The last method, however, appears to be the result of looking at the question in a broad-minded and unbiassed manner. The object desired is the rotation of the hands on a number of dials at a definite rate. Assuming that electrical connection to each is necessary to secure uniformity, why cannot the electric impulses be used not only to

synchronise the hands but to propel them, thus dispensing with the pendulum, the escapement, the four wheels, and the necessity for winding them up once a week, all at one stroke?

We have thus narrowed down the proposed methods, by the selection of one which, on theoretical grounds, we consider the best. Let us now consider what practical systems on these lines have been brought forward.

We believe the first was the Popp pneumatic system of Paris, Doubtless those of our readers who are acquainted with the boulevards, have often noticed the handsome cast-iron standards, each bearing three clock faces, which have their hands driven pneumatically. But for such purposes as this, electricity is infinitely superior to pneumatics.

Electric systems of this class are the work of Hipp and Grau (Peiyer Favager and Cie., Neuchatel), Van der Plank (La Precision Cie., Brussels), and Reclûs, Paris. The principal difficulties inevitably connected with all systems of this class are *(a)* the production of a safe and non-intermittent contact in the controlling clock, and *(b)* an absolutely reliable step by step movement for the dials; and to deal with them effectively the systems we have referred to contain some rather elaborate devices. To secure a good controlling contact the central clock is usually provided with a separate series of gear wheels or "train," from which the power is obtained for the purpose. This train and the ordinary clock train at its side, which lets it off every minute or half-minute, are usually supplied with power by a spring or weight wound up by hand once a week. The reliability of the "receivers" or dials is obtained by elaborate arrangements for locking the step by step movement. In one case a fly-wheel is employed, making a complete revolution every half-minute, and in another polarised armatures are used in conjunction with a double line, the current being sent in alternate directions each minute.

There seemed to be room for much improvement and simplification in these methods, and some two years ago a system appeared which obtained the two essentials—a safe contact in the controlling clock and

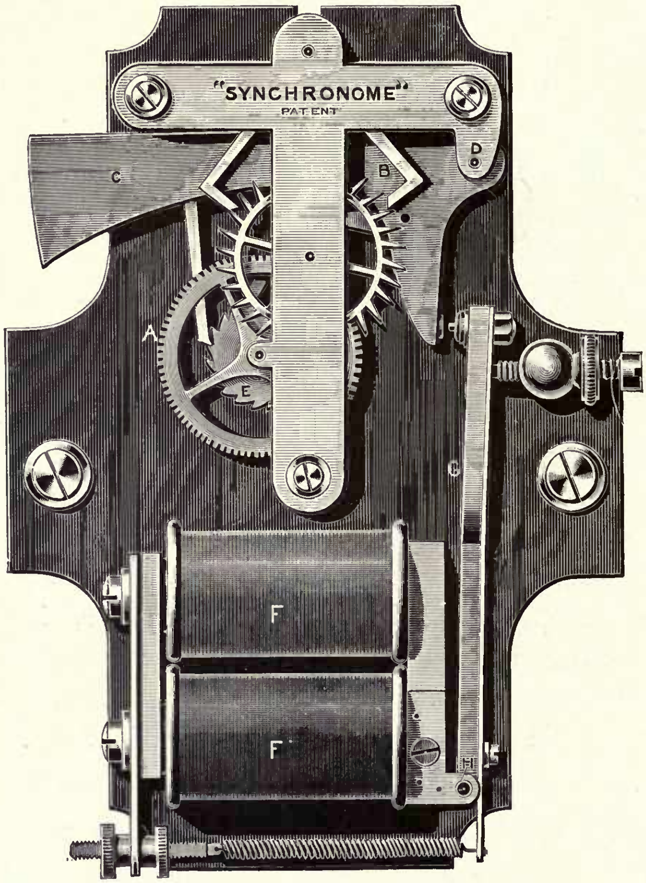
reliability of the secondary step by step mechanism—in a more simple and direct manner. This is known as the "Synchronome" system, and the inventors, Messrs. F. Hope-Jones and G. B. Bowell, cease to regard the central regulator or controller as a clock. They do not encumber it with a dial or hands, as they consider its specific functions of accurate time-keeping, and of sending out impulses to record it upon any number of indicating clock faces, is of far more importance. The instrument is thus nothing more than an automatic *timed switch*, and its only resemblance to a clock is that it uses a pendulum to regulate the periodicity of the switching operations it performs. A reference to Fig. 50 will show how this is accomplished.

The progression of the wheel A is controlled by means of an ordinary pendulum and the escapement B. C is a weighted lever centred at D, and bearing upon wheel A through the pawl and ratchet E. F is an electro-magnet, and G, its armature, centred at H.

The weighted lever, in falling, turns the wheels and keeps the pendulum swinging, but after it has fallen about one-eighth of an inch during a period of exactly half-a-minute, the lower arm of the lever meets the contact screw in the tail of the armature. The circuit of the electro-magnet is completed at that point, the armature is attracted, and the weight is thrown up again on to the next tooth of the ratchet wheel, and the cycle of operations repeats itself. As we have said, the sole object is to obtain a good contact every half-minute. Let us see how far this mechanism accomplishes the desired result, remembering that the principal virtue of a good contact is the severity of the rubbing and thrusting action of its surfaces, and that a pendulum's accuracy of time-keeping depends mainly upon the even feed of power applied to it through the escapement.

In all previous electric clocks the contacts for winding up the controlling clock and for sending out impulses to indicator dials, engage some moving part of the wheel-work. That is to say, their safety depends mainly upon the extent to which they rob the pendulum-driving mechanism of the power which properly belongs to it. But in the

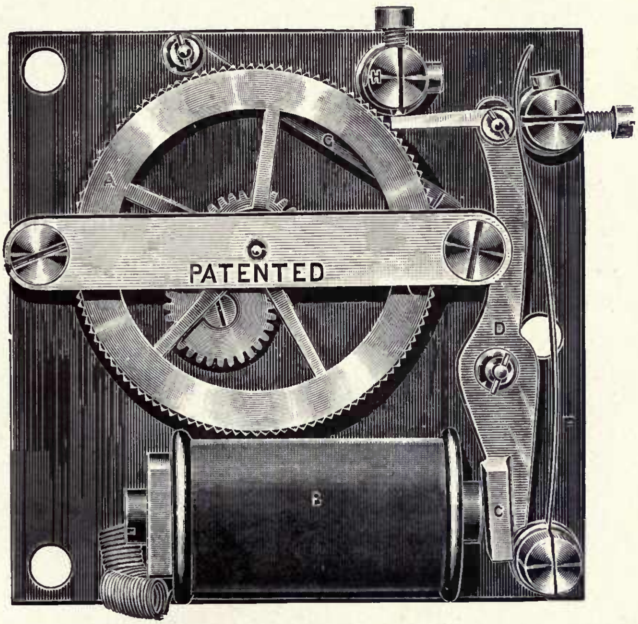
mechanism we have described, it will be noticed that the two functions of contact-making and time-keeping are entirely distinct. The energy devoted to the purpose of making the contact is considerable, and the



FRONT VIEW OF THE "SYNCHRONOME" AUTOMATIC TIMED SWITCH.
(F. Hope-Jones and G. B. Bowell, Patentees.)
FIG. 50.

resulting rub and thrust is excellent, but it is not derived from the wheel-work; on the other hand, it is obtained from the electro-magnet, in its act of imparting power to the clock. The wheel-work, therefore, is

subject to no interference in the fulfilment of its sole duty of keeping the pendulum swinging, and for that purpose it is fed with small instalments of power, meted out to it with perfect regularity every half-minute. The accuracy of time-keeping resulting is doubtless due, mainly to this even feed of power, and to the fact that the wheel-work is relieved of all extraneous duties; but the absence of the wheel-work, necessary to an ordinary clock wound up once a week, must also be a distinct gain from



BACK VIEW OF INDICATOR DIAL.
FIG. 51.

the point of view of time-keeping, as it is just that part dispensed with which is the principal source of friction.

The mechanism behind the "indicator dials" or receiving clocks is shown in Fig. 51, in which A is a wheel, having 120 rectangular teeth, connected with the minute hand. B is an electro-magnet, with armature C centred at D, and carrying a pawl at its end. F is a spring,

G a back stop click, and H and I are fixed stops. The impulses from the controlling clock pass through the electro-magnet each half-minute, causing it to attract the armature, and allow the driving click to pick up another tooth. The spring then carries it forward, the wheel remaining rigidly locked. The teeth being rectangular (each face at an angle of 45 degrees from the radial line), the driving pawl is free to slide out in response to the lightest electrical impulse, and is not in any way jambed although it provides a perfect lock.

The instrument is thus so sensitive that it will operate with a contact having a duration of only one hundredth part of a second. Moreover, it can never take up more or less than one tooth, whether the contact is long or short.

On these grounds this system appears to be by far the best of those we have classified under our third head. The author is well acquainted with it in separate installations, such as that in the Generating Station at Bradford, and there is no reason why time-circuits should not be laid down on a larger scale, to include dials at the more important street corners. The tenants of the adjacent buildings might then be invited to participate, by having the circuit led through their offices and becoming subscribers to a "public time service," at a rental of, say, £1 1s. per dial per annum.

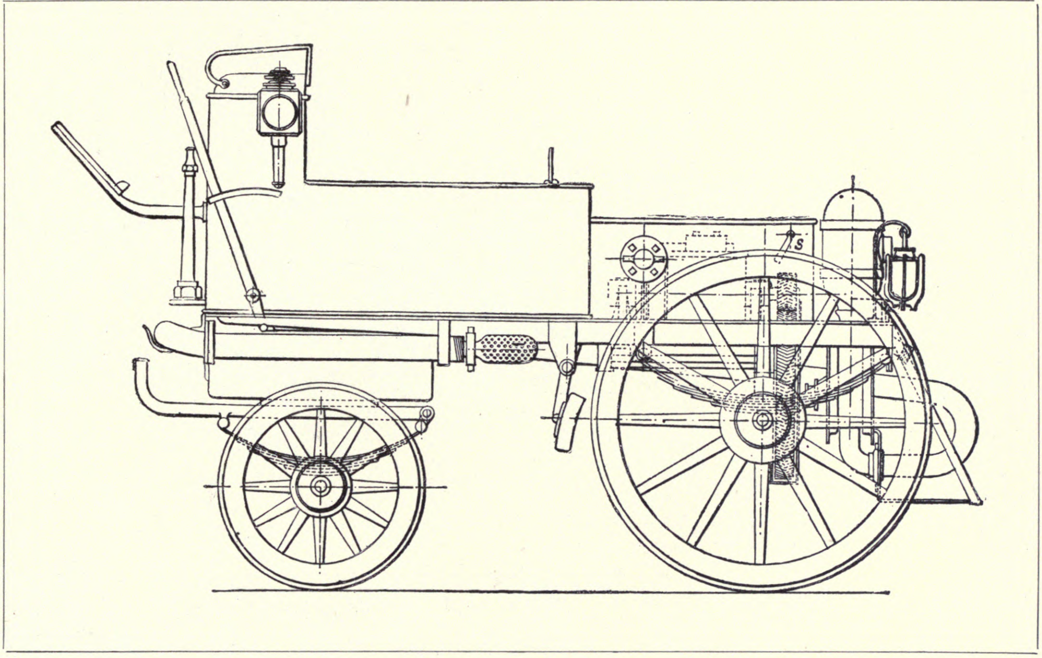
This should be a very paying business for a municipality, and the public would have the advantage of guaranteed Greenwich time, without having to wind up their clocks themselves, or entailing the cost of strangers coming into their premises for the purpose.

Electric Fire Engines.—One of the most useful applications of electricity in the future will undoubtedly be the employment of electric fire engines, either in the place of, or in addition to, those operated by steam. It will, of course, be many years before electric mains are laid as extensively as water mains, but the areas already supplied are very considerable in some towns. There can be no reason why, in such cases, an electric fire engine should not be added to the fire station equipment. It has, as a matter of fact, the great advantage that the

power required is at hand immediately. With the present engines, delay sometimes arises in getting up steam, and on an alarm of fire every moment is of importance.

Messrs. Siemens Brothers and Company have designed an electric fire engine, which is illustrated in Fig. 52.

The carriage and frame were constructed by Messrs. Merryweather and Sons, and are exactly in accordance with those supplied by this



Electric Fire Engine.

Fig. 52.

firm for use by the Metropolitan Fire Brigade. The frame is of mild steel, carefully stayed and supported on steel springs, high wooden spoke wheels, mail axles, and wrought-iron locking fore-carriage, capable of locking completely under the body, to facilitate turning in confined situations. The hose-box is of mahogany, forming a seat for the

firemen, and fitted with the usual hand-rails and driver's seat. A foot-plate is also fixed behind, to carry two men.

The pump is driven through helical gear by means of a Siemens motor, which is capable of developing 20 electric horse-power, at 1,000 revolutions per minute. The armature is of the gramme ring type, and drives directly a helical pinion which overhangs the main bearing, and is in gear with the rotary pump. The bearing brackets and electro-magnets are bolted to two longitudinal Z-iron pieces, which form the

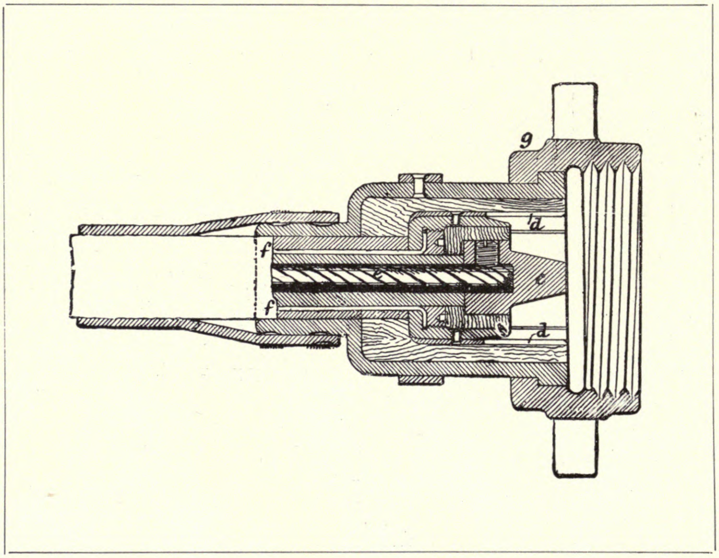


FIG. 53.

base of the motor, and are fixed to the frame of the fire engine, in the position usually occupied by the boiler. The electro-magnet cores are of wrought-iron, and are bolted to horizontal wrought-iron pole pieces, the lower one being screwed to the Z-iron frames. The bearings are in halves, and are supplied with sight-feed lubricators.

The rotary pump is of the double gear type of Merryweather's patented pattern, and is entirely of gun-metal. The pump is kept tight

by elastic packing in grooves, and glands are dispensed with on the shafts by cup-leather packings, and a special arrangement of passages, passing any leakage back into the suction side of the pump. A long flexible suction pipe, of four inches inside diameter, is carried round the engine, always attached to the pump, ready for immediate use. The delivery outlet is provided with a valve and lever, so that either of the

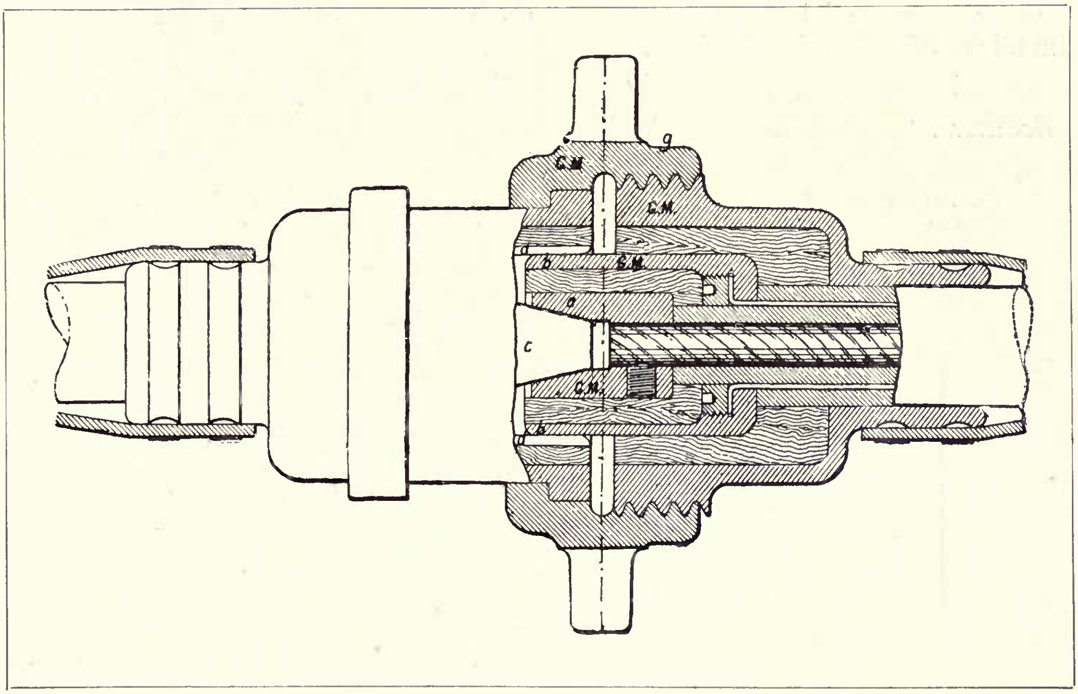


FIG. 54.

two outlets may be closed as required. The pump is driven by helical gear, at a reduced speed of about one to three from the motor, and the intermediate gear of the pump, which is fitted on both ends of the shaft, is cut in steel.

For connecting the fire engine on to the electric mains, a flexible concentric cable is carried round the engine in about 20-feet lengths.

The internal and external conductors, at one end of the first length, are respectively connected to the terminals of the motor through the necessary resistance and the controlling switch S, which are enclosed in a mahogany box, with suitable doors to give access for oiling, &c. The other end of this length is connected to a half-union, as illustrated in Fig. 53, either for attachment directly to the mains, or to be prolonged by the addition of other lengths, each of which is supplied with couplings, as illustrated in Fig. 54, and in that way any required amount of cable is obtained.

Experiments, made with the fire engine by Messrs. Siemens Brothers, are collected in Table XXIX.

TABLE XXIX.—*Experiments with Electrical Fire Engine.*

Watts expended	Gallons of Water per Minute	Pressure in lbs. per sq. inch	Size of Nozzle
27,500	120	170	$\frac{5}{8}$
20,700	160	125	$\frac{3}{4}$
16,500	180	100	$\frac{7}{8}$
12,800	190	70	1

In order that electric fire engines may be operated at any point in the district supplied by electricity, a pillar is fixed near each hydrant, as represented in Fig. 55, or, if more convenient, a wall-box, as shown in Fig. 56. Each is connected with the mains by two insulated conductors, which are brought up and connected respectively to the two connecting tubes, *a* and *b*, by means of terminals T (Fig. 56). The inner tube *a* is turned out conically at its outer end, for the purpose of receiving the corresponding plug when the fire engine is to be attached; and connection is at the same time made with the outer tube *b*,

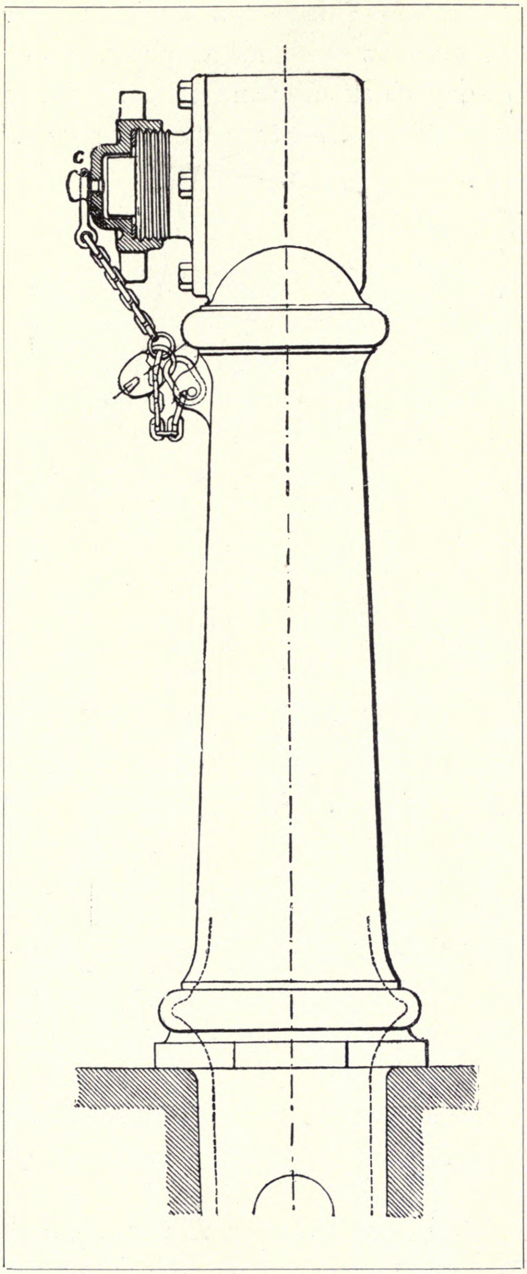


Fig. 55.

by means of a corresponding split tube which slides over it.

This arrangement is shown in detail in Fig. 53, which represents one half of Messrs. Siemens Brothers' concentric cable union, the complete union being shown in Fig. 54. When not in use, a watertight gun-metal cap C, is screwed into position (as shown in Fig. 55), and is secured to the pillar or wall-box by means of a chain.

The inner conductor *e* (Fig. 53) is in connection with a conical-shaped plug of metal C, which fits accurately the inner tube *a* in the post. The outer conductor *f* terminates in a split tube *d*, so that when the union is screwed home, the tube springs open and makes good metallic contact with the tube *b*. Each conductor is thoroughly insulated, and the union is held in position by a gun-metal ring *g*, which is provided with lugs, as shown.

On the arrival of the engine, the fireman has simply to unscrew the cap C, and connect up the concentric cable in the manner described, and the engine is ready for use.

Automatic Electric Clock and Switch.—This is an apparatus for automatically switching on and off any number of lights at pre-arranged times. It consists of an ordinary eight-day clock movement gearing with simple mechanism, which throws a mercury switch either "on" or "off."

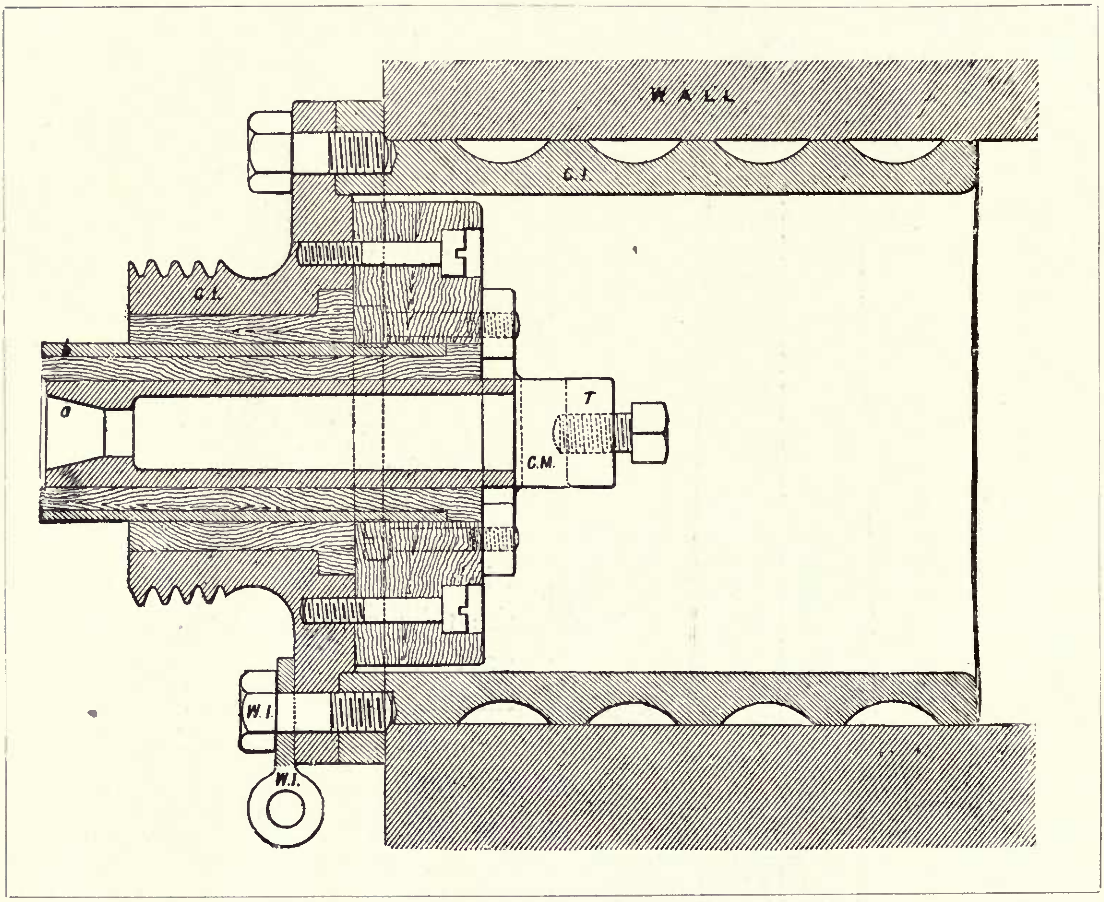


Fig. 56.

Fig. 57 shows the external appearance of the apparatus, which is enclosed in a stout cast-iron case, with bevelled glass front. Special damp-proof cases with leading-in glands are supplied for outdoor work. The large

dial to the left is that of the clock, while the dials to the right are the "switch on" and "switch off" dials respectively. These are divided off into twenty-four hours, and the index on each has merely to be turned by a thumb-screw to the time at which the switch is to be operated. Supposing the clock is wound up, and the top and bottom dials set at 1 a.m. and 7-30 p.m. respectively, the lamp or lamps will be switched

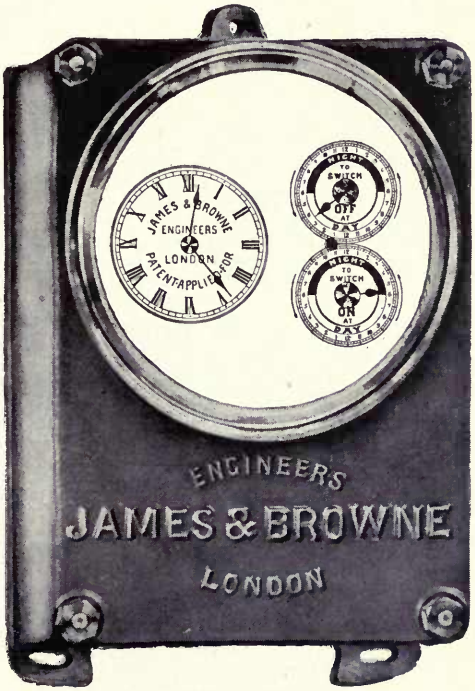


Fig. 57.

on regularly for a week every evening at 7-30, and off again at 1 a.m., without any attention being necessary. The mechanism contains no magnets or solenoids, and no contacts besides those of the mercury switch, the latter being quick-break in action. The apparatus may be used to control any number of lamps, that for larger currents being fitted with a relay. The usual size without relay will carry 12 ampères.

The uses of such a device are many. For instance, it is already employed in street lighting, being fitted in that case in the lower part of the lamp-post. For shop-window lighting, where it is the custom to have the windows illuminated after business hours, it has met with a favourable reception. Another field for its use is in connection with electrical advertising signs. The makers of this electric clock-switch (which, by the way, is the first of its kind) are Messrs. James and Browne, 39 Victoria Street, Westminster, London, S.W.

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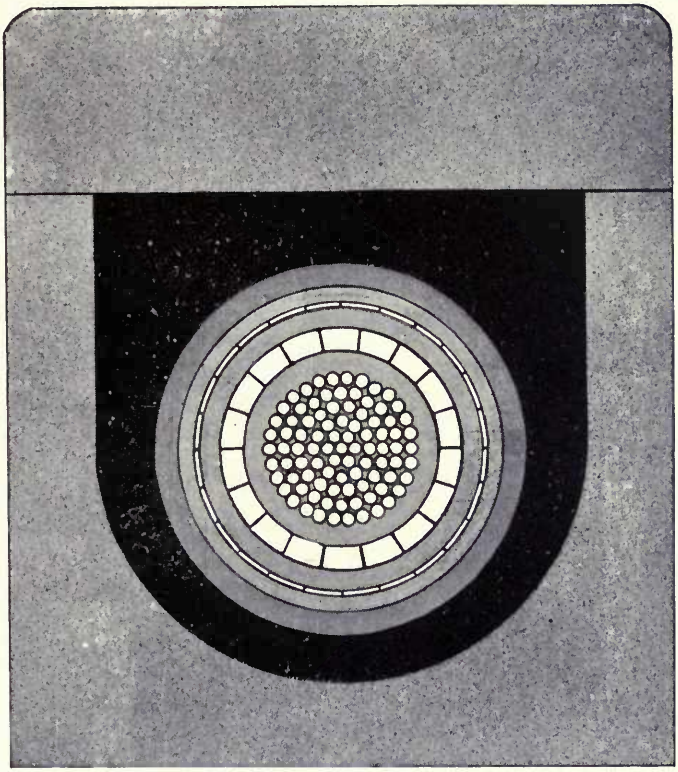

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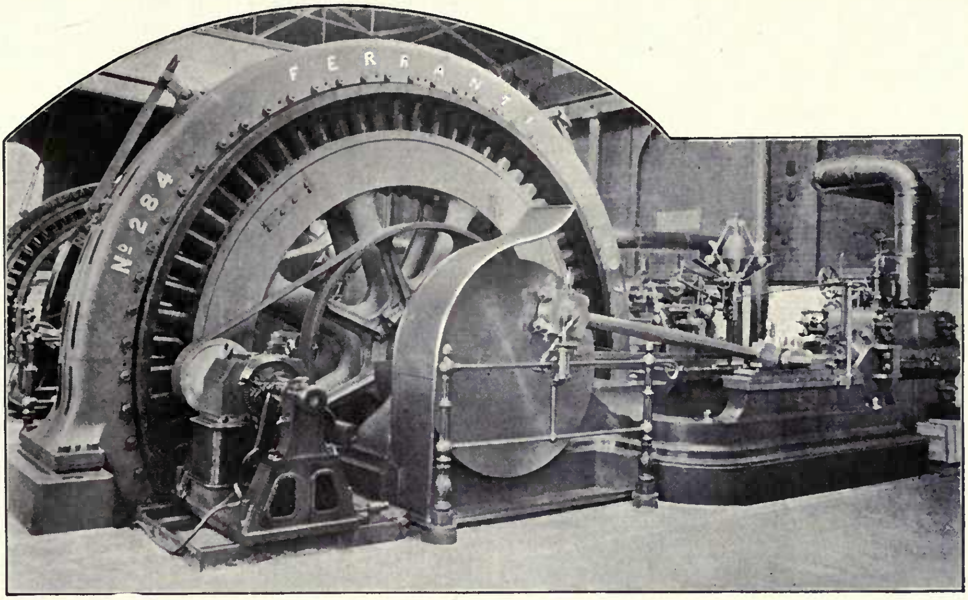

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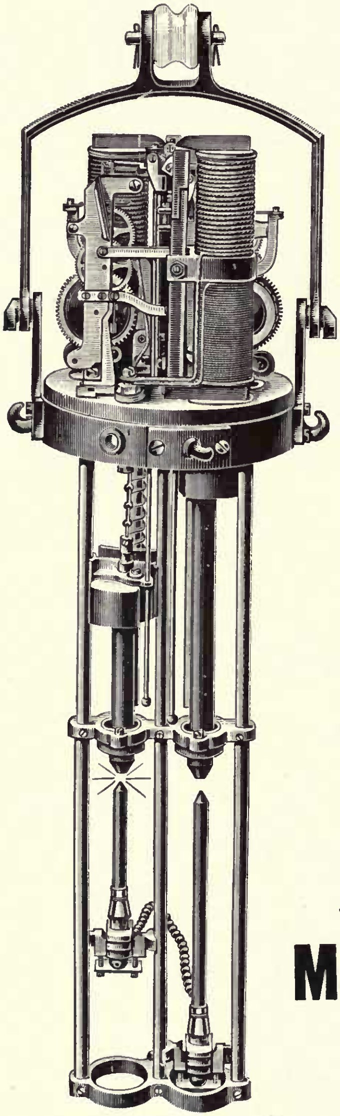

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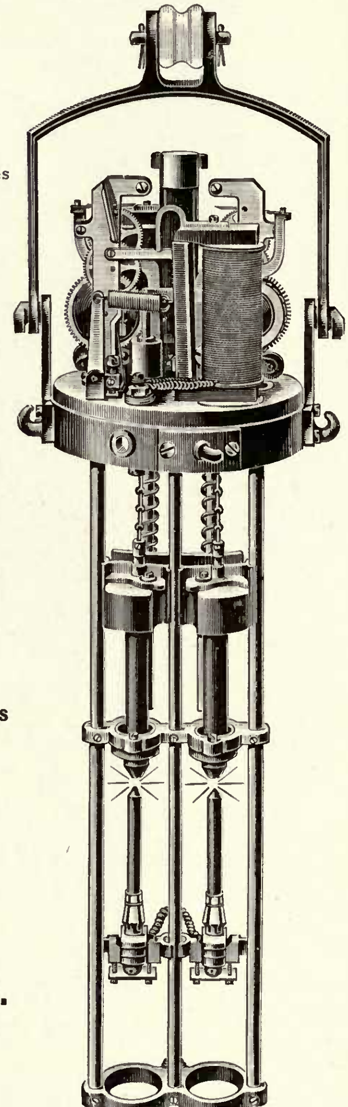

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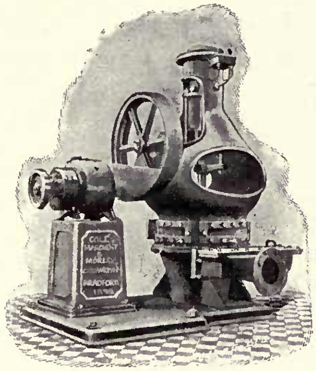

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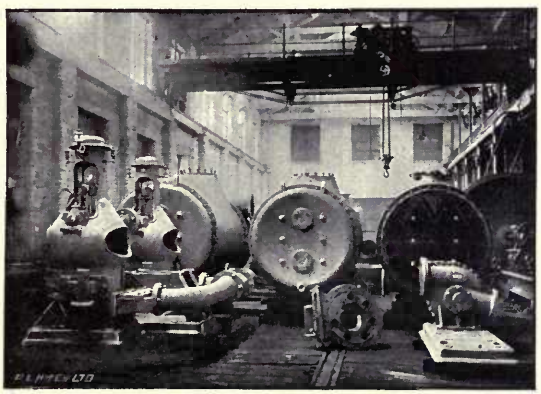

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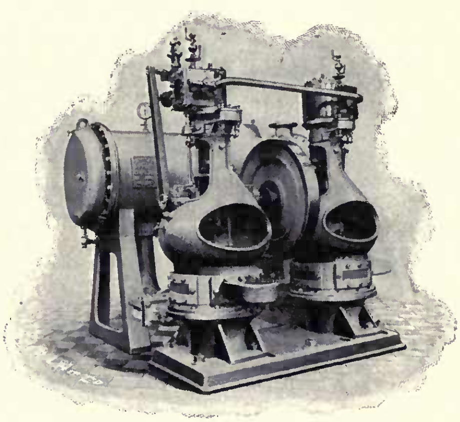

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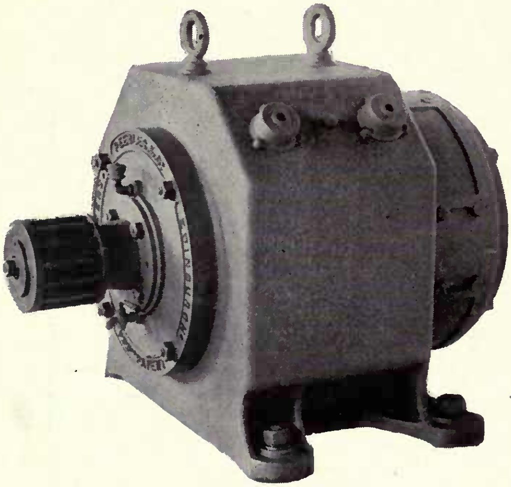

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High efficiency, first-class workmanship, and the best design possible for the work has been our aim, and the enormous amount of work we have now in hand shows us we are not altogether unsuccessful.

STOCK SIZES ... ... 1—40 H.P.

DIRECT COUPLED PLANTS ... 50—250 H.P.

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